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BRITISH INSECTS

BRITISH INSECTS

AND HOW TO KNOW THEM

BY

HAROLD BASTIN

WITH TWELVE PLATES

METHUEN & CO. LTD.
36 ESSEX STREET W.C.
LONDON

First Published in 1917

PREFACE

THE aim of this little book is to provide a popular introduction to the study of British insects. It has been penned more from the standpoint of the naturalist, whose interest lies with the structure and habits of living things, than of the systematist, whose chief object is to discover and record their inter-relationships. But the naturalist cannot hope to advance far in his pursuit without a "working knowledge" of classification to guide him. Therefore an attempt has been made to indicate the chief reasons why insects are separated by men of science into groups—orders, families, genera, etc. The "outline classification" printed on page 120 is adopted from Professor G. H. Carpenter, whose articles in the current edition of the "Encyclopædia Britannica," and whose work, "Insects: their Structure and Life," may be consulted with advantage by the serious student. Dr. David Sharp's two volumes on "Insects" (which form a part of "The Cambridge Natural History") should also be read and reread. It is to be hoped, however, that those who may be

induced by a perusal of the following pages to commence the study of insects will not rest content with booklore. The life-histories of so many common species still await investigation, that the veriest tyro may reasonably hope to make discoveries on his own account, if only he will work honestly and well.

I wish to offer my thanks to my friend the Rev. Canon Fowler, D.Sc., M.A., who helped me to correct the proofs, and suggested several emendations.

I have also to acknowledge my indebtedness to Messrs. T. C. and E. C. Jack for their permission to reproduce (from my book, "Insects: Their Life-Histories and Habits") the photograph of the May-fly which appears on Plate IV.

H. B

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BRITISH INSECTS

BRITISH INSECTS AND HOW TO KNOW THEM

CHAPTER I

INSECTS IN GENERAL

PROBABLY most of us believe that we know an insect when we see one; but if we were asked to put our conception into words, we might find ourselves in difficulty. Everyone has heard of the railway porter who was faced with the necessity of classifying a tortoise for purposes of freightage. He is reported to have laid down the law somewhat as follows: "Cats is dogs, and monkeys is dogs, but this here's an insect and don't count." The fact is that the term insect, when used in its scientific sense, has a much more definite meaning than many people realize. At one time it covered all the members of the vast group known as the Gnathopoda, or "foot-jawed" animals,[1] including crabs, lobsters, spiders, ticks, centipedes, and many less familiar forms of life. But nowadays, by common consent among naturalists, it is reserved for that particular section, or class, of the Gnathopoda to which the alternative name Hexapoda ("six-footed") has been given. Thus, when a naturalist speaks of an insect, he means in the first place that the creature in

[1] Also called the Arthropoda—*i.e.*, "with jointed feet."

question has six legs, a distinction which at once puts crabs, lobsters, spiders, ticks, centipedes, etc., out of court. Here, then, we have a sure foundation upon which our knowledge of insects may be based. But their six-footedness is only one among many characters which serve to separate insects from all other animals. So that before we discuss British insects in detail, we shall do well to consider briefly the peculiarities of insects as a class.

The name "insect" is derived from the Latin verb *insecare* ("to cut into"), and is very appropriate, since the typical insect's body is divided into three sections—viz., the head, the thorax, and the abdomen. These parts are not always obvious, especially in young insects such as caterpillars and grubs; but we shall see later that even in these cases the tripartite plan is already sketched out, as it were, and waiting to be revealed when the final stage of the life-history is reached. Each of the three main sections of the insect's body is made up of rings or segments. In the head always, and often in the thorax, these are so intimately fused together that the lines of juncture are practically obliterated; but in the abdomen most of the segments can usually be distinguished without difficulty. This segmentation of the body is an important point, because it serves to support the view now held by scientific men that insects have descended from worm-like ancestors—creatures whose body was composed of a simple head-lobe followed by a series of nearly identical rings, each of which carried a pair of locomotor appendages or "feet." This idea, once firmly grasped, explains many details of insect structure that might otherwise prove difficult to comprehend. It will help us, for instance, to understand

the insect's mouth-parts, or "jaws," of which there are three distinct pairs. There is reason for thinking that these three pairs of mouth-parts trace their origin to a corresponding number of appendages which belonged to segments behind the head-lobe of the early ancestral stock. Nature, in fact, seems to have "telescoped" the parts, with the result that the "head" of the modern insect includes several rings, or segments, that were quite distinct therefrom in its remote progenitors. Possibly these archaic beings developed an appetite for harder foods than they had erstwhile eaten. Be this as it may, there seems no room for doubt that certain of their body-rings were pushed gradually forward, so to speak, into the immediate neighbourhood of the mouth, and that the appendages carried by these rings were turned inwards, so that each pair could be used for nipping and biting. This is why the above-cited group of animals (including insects) is called Gnathopoda, or "foot-jawed."

In the case of an insect, such as a cockroach or a cricket, which subsists upon solid food, the position of the mouth-parts is not difficult to make out. There is first a kind of plate, called the upper lip, or *labrum*. This is hinged to the head in the middle line, and behind it are the three pairs of jaws, or foot-jaws, termed in the order of their arrangement the *mandibles*, the *first maxillæ*, and the *second maxillæ*. The mandibles are powerful nipping organs, specially designed for breaking up hard or tough substances. The maxillæ of both pairs are much more delicate structures, and probably serve to mince the food finely, or to pass suitable fragments into the mouth—*i.e.*, the opening which leads to the gullet. Unlike the mandibles, each

of which is in one piece, the maxillæ retain their primitive jointed character, being severally composed of two basal parts and two lobes. Moreover, each maxilla carries a little feeler, termed a palpus. The first maxillæ are always separate, but the basal parts of the second pair are generally more or less closely united. For this reason naturalists usually refer to them *en masse* as the lower lip, or *labium*. The only other mouth-part that need be mentioned here is a kind of skinny fold on the inner, or front, side of the labium, which is known as the tongue, *lingua* or *hypopharynx*.

The would-be student of insects should form a clear mental picture of the relative positions occupied by these mouth-parts, and familiarize himself with their technical names. He will then be able readily to appreciate the nature of the changes, or modifications, which fit insects to partake of different kinds of food; for the above generalized description applies only to insects of the mandibulate or biting type, and there are many kinds which feed either wholly or in part on liquids. Some suck nectar from the flowers. Others pierce the skins of plants or animals and extract the sap or blood. Such methods of feeding obviously demand special adaptations of the mouth-parts, and in subsequent chapters we shall see how marvellously these have been effected.

In addition to the mouth-parts, the head of an insect carries eyes and a pair of antennæ. The latter are often "feelers," used by their owner to explore foreign objects; but in many insects the antennæ are undoubtedly the chief seat of the sense of smell, while they may possibly serve other senses as well. The diverse forms of the antennæ in different kinds of

insects suggest that their functions may be almost equally varied. Insects may have two kinds of eyes —simple and compound. Each simple eye, or ocellus, is a small polished lens set above a cup-shaped retina, which is connected by nerves with the brain. Certain young insects (*e.g.*, a caterpillar) have little groups of these eyes on each side of the head; but in the adult, if they are present at all, the ocelli usually occupy a central position. A bee, a wasp, or a dragon-fly, has three of these eyes arranged in a triangle upon its brow. So far as we are able to judge, the ocelli are exceedingly "short-sighted," and are probably more serviceable in distinguishing light from darkness than in forming images. The compound eyes, of which most adult insects have a pair situated one on each side of the head, are very marvellous organs. The surface layer, or cornea, is composed of numerous facets, or separate lenses, connected with the brain by an extremely complex nervous mechanism. It is possible by the aid of the microscope to photograph an object, such as a postage stamp or the flame of a candle, through the isolated cornea of an insect's eye; and when this is done, we obtain a multiplex picture of the object—one image, in fact, for every facet in the cornea. This interesting experiment led certain of the early naturalists to conclude that the compound eyes present a multitude of separate images to the insect's brain. In the case of some hawk-moths the number would be something like 27,000 for each eye! Of what use this amazing portrait gallery could be to the creature concerned, no one attempted to explain. We need not pass in review all the learned disputations to which the problem of insect vision has given rise. Suffice it to say that the theory of a multiplex

image has been discarded. It is now believed, for good and sufficient anatomical reasons, that each facet of the eye registers in the brain not a complete picture, but merely the small part of the picture which happens to be exactly opposite the centre of the lens, and that all these fragmental images combine in the retinal region of the eye. A mosaic pavement, composed of numberless pieces of stone or marble in close contact, helps us to grasp the idea. Indeed, we may take it as highly probable that an insect's visual perception of an object does not differ greatly from our own, although we know very little concerning the actual power and extent of any insect's sight.

Behind the insect's head, to which it is joined by a slender "neck," is the thorax, which often appears to be one piece, but is, in reality, composed of three closely fitting rings, or segments, termed *pro-*, *meso-*, and *metathorax* respectively. Each segment of the thorax carries a pair of jointed legs, which vary greatly in form in different kinds of insects. In almost every instance, however, the five principal parts of each leg may be easily distinguished. The haunch, or *coxa*, fits into a socket in the thorax; then follows a small joint called the *trochanter*, which is sometimes divided into two; after this comes the thigh, or *femur;* then the shin, or *tibia;* and finally the foot, or *tarsus*, which may consist of from one to five joints, the usual number being five. The last, or distal joint of the tarsus, is usually furnished with a pair of claws. It is worth while fixing these technical terms firmly in the mind, because they have a much more definite meaning than any possible English equivalents. The tarsus of an insect, for example, is something very different from a "foot" in the ordinary sense of the word.

The second and third segments of the thorax may each carry a pair of wings. These are unique structures, since they are not possessed by any other invertebrate animals. Moreover, whereas the wings of a bat or a bird are really modified fore-limbs, those of an insect are expansions of the outer case or exoskeleton. They consist of two layers in close contact, supported upon a tubular framework of "veins," which are called "nervures." Only adult insects have functional wings, and no insect has more than two pairs.

In some insects, such as beetles, the fore-wings are more or less hardened and thickened, and act as protective covers,[1] beneath which the more delicate hind-wings are folded when they are not in use; in others (*e.g.*, bluebottles and house-flies), the second pair of wings are reduced to small, stalked knobs called "balancers," or "halteres," useless for flight, but perhaps serviceable in assisting the insect to maintain its equipoise in the air. In other insects, again, we find that the fore-wings are very small or absent, while some insects have no wings.

The probable origin of insects' wings is a much-debated question which need not concern us here; but it is well to remember that the wings are very important organs from the standpoint of the systematic naturalist. A knowledge of their various peculiarities, and of the different types of mouth-parts, enables him to sort up insects, so to speak, into their proper tribes, clans, or family groups.

Behind the thorax of the insect there is frequently a kind of stalk, or "waist," usually very short, and often quite hidden from view, which connects with

[1] Called *elytra*.

the hindmost section of the body—the abdomen. The latter is made up of a varying number of rings or segments, some of which are often fused together and otherwise modified, so that their identification is difficult. For the most part, however, the segments form a more or less flexible series, thus permitting the tip of the abdomen to be moved from one point to another. Since the six legs of an adult insect are all attached to the thorax, the abdomen must be described as legless; but it frequently carries appendages, which probably represent the paired "limbs" that were present on the posterior segments of the wormlike ancestral stock. Indeed, among certain of the lowliest existing insects we shall see that the abdominal appendages still assist locomotion. In many insects (*e.g.*, cockroaches and May-flies) the extremity of the abdomen bears two, or three, antennæ-like processes, termed "cerci," which appear to be sense-organs — perhaps tactile or olfactory. Finally, we find that the tip of the abdomen is usually adapted to meet the requirements of the reproductive processes. In the female insect there is often an elaborate egg-laying apparatus, or ovipositor.

We have now constructed a kind of mental key to the outward form of an insect. It remains to be said, however, that the visible crust, or cuticle, of the creature is not its true "skin" in the strict sense of the word. It consists of a peculiar non-living substance, horn-like in appearance, but chemically quite distinct from horn, termed *chitin*. This is excreted by the underlying layer of living cells which form the true outer skin, or epidermis. The insect has no bony skeleton. Its soft tissues are supported and held together by this outer layer, or exoskeleton, to which

EMPTY EGG-SHELLS

COCOON ON BARK

LARVA OR CATERPILLAR

EMPTY PUPA-SKIN

PERFECT INSECT

METAMORPHOSIS OF PEAS MOTH

also the muscles are attached. In adult insects the chitin is often deposited as thick, hard plates, like armour; but in many young insects, such as caterpillars, the layer is very thin, flexible, and transparent.

Another point that calls for explanation is the manner in which insects breathe. They have no lungs, nor is their blood pressed into service to carry oxygen to the tissues. Atmospheric air passes into the body through small openings called "spiracles," some of which may be seen along the abdomen of the poplar hawk-moth, whose photograph is reproduced on Plate IX. After entering the spiracles, the air circulates through a system of minute tubes, or tracheæ, which ramify among the insect's living tissues, and supply to them the oxygen requisite for the various vital processes. The air-tubes, or tracheæ, are formed by an in-pushing of the outer skin, or epidermis, and their inner wall is supported by a spirally coiled thread of chitin. Thus, when an insect moults (we shall see shortly that this is a frequent occurrence while growth is proceeding) it discards not only its crust, or exoskeleton, but the lining of its tracheæ as well.

With the internal organs of the insect we have not space to deal. Since, however, we shall find much food for thought in the behaviour of insects—their individual habits, parental activities, and apparent cuteness in surmounting the difficulties of their every-day life, it seems well to state that these creatures are endowed with a highly developed nervous system, which differs in important respects from that of a vertebrate animal. In its more simple, ancestral form, the insect's central nerve-cord was composed of

two distinct threads running within the lower, or ventral, wall of the body—its location being thus below the digestive canal, not above it, as is the case with a fish, a reptile, a bird, or a mammal. In each segment the twin threads were swollen, forming paired knobs, or ganglia; and each ganglion constituted a kind of "brain" which governed the affairs of its own immediate surroundings, but was little concerned with those of neighbouring segments, albeit a certain amount of nervous exchange would take place to insure perfect co-ordination of the various bodily functions. So, at least, we may figure the nerve mechanism of the primitive insect; and even to-day the same principle obtains, although in most modern insects the mechanism itself has been greatly modified many of the originally separate ganglia being incorporated. One such mass, called by courtesy "the brain," is found in the front part of the head. It is connected by nerves with the eyes and the antennæ and exercises a kind of controlling influence where movements of the legs and wings are concerned. Yet a brainless insect can walk or fly in an aimless erratic manner, because the actual motor nerves, which send stimuli to the muscles of the legs and wings, go to ganglia in the thorax; it can also eat if food be placed in contact with its mouth-parts, the reason being that the nerves from the latter and their palpi are connected with a ganglion (next behind the brain) situated beneath the gullet.

In view of these facts, it is scarcely surprising to learn that insects are lacking in intelligence. True some of the more highly organized kinds appear to "remember," and to profit by experience to a limited extent; but in most of their actions insects are many

festly enslaved by the impulses of instinct. What instinct is we do not know, but we may see it working in numberless ways on any summer day. Without instruction or opportunity for imitation, insects perform all manner of intricate tasks for their own or their offspring's good. The only possible inference is that each succeeding generation of insects inherits from its parents a self-acting nervous machinery, comparable to an elaborate piece of clockwork, wound up and ready to perform its destined movements as soon as the spring is released. The release of the spring in the case of the insect appears to be effected by some simple stimulus, due either to internal or external causes, of which we know next to nothing. In this way the wheels are set going, so to speak, and the whole marvellous sequence of the creature's inherent skilfulness is reeled off.

We must now turn our attention to the growth and development of insects. With few exceptions, insects lay eggs. In the case of some lowly kinds, the young, when they hatch, are miniature reproductions of their parents. They simply increase in size as they grow from youth to maturity. But in the vast majority of insects growth and development involve a more or less marked form-change, or metamorphosis. The growing insect, in fact, casts its outer cuticle at stated intervals in its life-history; and in most instances each succeeding moult renders it less like its pristine self and more like its adult forbears. Take, for example, the cockroach and the mole-cricket. In each case the newly hatched insect has much the same form as its parents, but is destitute of wings. These organs develop gradually as growth proceeds, becoming more and more noticeable after each moult, but remaining

functionless until the cuticle has been cast for the last time. Indeed, until the final or adult stage of the life-history is reached, the wing-rudiments lie within pockets of the chitinous outer crust. Higher in the scale of insect life we find still more striking metamorphoses. The uninitiated would fail to connect the sluggish, mud-coloured young of the dragon-fly with the alert and resplendent winged being by which it was begotten. Highest of all, we find such insects as butterflies, bees, and two-winged flies, which begin life as a hungry caterpillar, grub, or maggot, pass through a period of quiescence when no food is taken, and then undergo a final moult before reaching sexual maturity. In these last-named cases the wing-rudiments lie hidden within little pockets or in-pushings of the true skin or epidermis until the quiescent stage of development is reached; but at the period of the penultimate, or last-but-one, moult, they are withdrawn, and at its conclusion are plainly visible beneath the newly-formed cuticle or exoskeleton.

Several convenient terms are used to describe insects in different stages of their metamorphoses. When there is no quiescent period, the creature is usually referred to as a *nymph* from the time when it leaves the egg until it becomes adult. But when the life-history, subsequent to hatching, exhibits three strongly contrasted stages, the insect is known first as a *larva*, then as a *pupa*, and finally as an *imago*, or adult. The term "larva," which is applied to any young animal that differs markedly from its parents, is in practice often discarded in favour of a more expressive substitute. Thus, when the larva is soft and cylindrical, with pairs of short, stumpy "prolegs" on certain of its hinder segments, it may properly be

called a *caterpillar*. When it is almost or completely legless, soft as to the cuticle, but with a hard head and well developed mouth-parts, the word *grub* may be employed. And when all trace of limbs of any kind have disappeared, while the head and its appendages evince signs of much simplification, the larva is usually spoken of as a *maggot*. In like manner the pupa of a butterfly is often called a *chrysalis;* strictly speaking, however, this term can only be used to describe pupæ (like those of the "tortoiseshells" and "fritillaries") that have brilliant metal-like areas on their surfaces, since it is derived from a Greek word signifying "gold."

The facts of growth and development which have been briefly set forth above appear to indicate that metamorphosis was not a feature of the primitive insect's life-history. The lowliest existing insects have no metamorphosis; higher in the scale metamorphosis is slight, or incomplete, while only among the more highly specialized forms is it strongly marked, or complete. From this we are led to infer that metamorphosis is not a necessary concomitant of growth and development, but a "special adaptation" to peculiar and transitory needs. The habits and surroundings of the young cockroach or mole-cricket are practically identical with those of its parents. Thus, it need not differ from them in form or faculty. But among the higher insects the environment and food-habits of the young constitute a unique phase in the life-history. The dragon-fly nymph dwells in the water, gaining its livelihood rather by stealth than by alertness, whereas the adult dragon-fly spends most of its time hawking insects in the air; the caterpillar chews up leaves, while the butterfly sucks nectar

from the flowers; the bee's grub is exempt from all self-effort by the instinctive provision made by its parent, or by adult members of its community. In view of facts such as these, and because every animal is seen to fit accurately the particular niche which it occupies in the scheme of existence, it is scarcely surprising that the larvæ of many insects differ widely from their adult forms; nor can we wonder that an intervening period of quiescence (the pupa stage) has become necessary to bridge over the gap which exists between the two totally distinct phases of life. To quote the late Lord Avebury, the necessary transformation, in the case of a caterpillar, "could hardly take place while the insect was growing fast, and consequently feeding voraciously; nor, if the change could be thus effected, would the mouth, in its intermediate stages, be in any way fitted for biting and chewing leaves. The same reasoning applies also to the digestive organs. Hence the caterpillar undergoes little, if any, change, except in size, and the metamorphosis is concentrated, so to say, into the last two moults. The changes then become so rapid and extensive that the intermediate period is necessarily one of quiescence."

Before concluding this chapter, a few words must be said respecting classification. Formerly its chief aim was to arrange things in convenient groups according to their obvious agreements and differences. But nowadays the schemes of classification put forward by naturalists are deliberate attempts to express relationship—not mere outward similarity, be it noted, but actual kinship. For since the days of Charles Darwin naturalists have become firmly convinced that all existing plants and animals have descended

in unbroken succession from the much simpler forms of life which inhabited the earth in the remote past. We have already seen that insects appear to have been derived from a worm-like ancestral stock. This much is admitted by all those who are qualified to speak; and when these authorities agree to alter the classification of insects in any way, this means that they have made a fresh discovery. They have unearthed some evidence of relationship hitherto obscure, and are thus able to add to our knowledge of insect lineage. We must bear in mind, however, that all schemes of classification must be somewhat artificial, because for the sake of convenience we have to group together those kinds of insects which seem to be most nearly akin. These groups have no real and separate existence in the long sequence of insect life upon the earth. Just as past, present, and future become merged in eternity, so the countless generations of insects which have succeeded one another since the race began combine to form one immense family tree.

For the method of classification now in use we are indebted to the great Swedish botanist, Carl von Linné, or Linnæus, as he is often called. He gave names to all the kinds, or *species*, of plants and animals that were known to him, and assembled the species which seemed to resemble each other most closely into little groups, each of which he called a *genus*. In this way every species received two names—a generic name, common to the group, and a specific name, exclusive to the particular plant or animal concerned. Take, for example, our three common black and white butterflies, which belong to the genus *Pieris*. The large white is called *Pieris brassicæ*, the small white *Pieris rapæ*, and the green-veined white

Pieris napi—the three specific names having reference to the kinds of plants on which the caterpillars feed. The Latin names of insects often, but by no means invariably, suggest some peculiarity of the species in question. Their chief justification, however, consists in the fact that they bear a precise meaning to the mind of the student, no matter what his nationality may be. The words "large white butterfly" might lack significance to the German, the Frenchman, or the Russian; but if he had studied insects, he would know at once what *Pieris brassicæ* meant.

Linnæus massed his genera into still larger groups, which he called *orders*, and these again into *classes*. These terms are still in use, but since Linnæus's time it has been found advisable to bring in another kind of group—the *family*—between the genus and the order; while the large groups are often split up into smaller ones, called sections, sub-orders, sub-families, etc. It is important to remember that all these divisions, although artificially contrived, are nevertheless intended to express our knowledge of the "natural" affinities of insects. The several species of the same genus are more nearly akin than species which belong to two or more distinct genera; the hundreds (it may be thousands) of species which go to make up a family are all bound together by definite characters, which are not seen outside the confines of the group; and so on until we come to the class, which comprises *all* the animals of the insect (alias hexapod) type.

CHAPTER II

FISH-INSECTS, EARWIGS, COCKROACHES, AND THEIR ALLIES

THE first main group, or order, into which the class Insecta (or Hexapoda) is divided is termed Aptera. Its members are all tiny, wingless insects with delicate biting mouth-parts. They undergo no metamorphosis, the newly hatched young exactly resembling the adults except in size. Whether the Aptera are really "primitive" in the sense that they have sustained little or no modification since they branched off from the original ancestral stock, or whether they once climbed to a high level of winged efficiency and subsequently retrograded to their present state, are moot points; but they are certainly the simplest of all living insects. Perhaps the best known species is the little "silver fish," or "silver lady,"[1] which is essentially a household insect, dwelling in cupboards, boxes, and among shelving, where it feeds upon a variety of vegetable substances, and at times damages books, etc., by gnawing away the surface of the paper. Its body — aptly described as "carrot-shaped" — is completely covered with minute, silvery scales. The pointed tail-end carries three long, slender cerci, whence the name "bristle-tails" is often applied to this insect and its near relatives. The antennæ are

[1] *Lepisma saccharina.*

even longer than the cerci, and very mobile, while the legs move with extraordinary rapidity; so that, despite its skulking habits, Lepisma is wonderfully alert and agile, and on the smallest alarm scuttles nimbly to some place of hiding. A very similar species, but with a more pronounced taste for the good things of life, frequents especially London warehouses and bakeries, where it is known as the "fire brat," or "baker's brat." Science calls it *Thermobia furnorum*. A third, nearly white, species[1] is fairly common among dead leaves and garden mould; while a fourth species,[2] which looks like a large brown Lepisma, abounds among heaps of loose stones at some spots on the coast.

All the above-cited species, which, with their near relatives, make up the bristle-tailed section (or sub-order Thysanura) of the Aptera, have ten abdominal segments, some of which carry pairs of small "limbs"; though whether these are used to assist locomotion is not definitely known. A second section (sub-order Collembola) includes the quaint little insects known as "spring-tails." They are usually much more compactly built than their bristle-tailed allies, with only six evident abdominal segments; but the most characteristic feature in many species is a forked appendage, lying beneath the body and actuated by muscles, by means of which the creature is able to hurl itself into the air—whence the popular name. Spring-tails of various species are very common in decaying vegetable matter, on herbage by the road-side, and on the banks of ponds. Other kinds disport themselves upon the surface of water, both fresh and salt, and are able to sustain long periods of submersion.

[1] *Campodea staphylinus*. [2] *Machilis maritima*.

COMMON AND LESSER EARWIGS

A MEADOW GRASSHOPPER
(Stenobothrus)

Tettix bipunctatus

BUSH CHEEP
(Thamnotrizon)

HOUSE-CRICKET
(Gryllus)

Ectobia lapponica

One such species[1] lives amongst the rocks on the shores of the English Channel, between the tide-marks. Yet spring-tails, their ubiquity notwithstanding, have so far failed to attract much attention on the part of serious students, and we know very little concerning their manner of life.

The earwigs[2] used to be included with the cockroaches and their allies, but because their true affinity is uncertain, they have wisely been accommodated with an order of their own, called Dermaptera. There are eight British species, but only two of these are at all common — viz., the lesser earwig[3] and "the" earwig.[4] The former is small (about a quarter of an inch in length), and is much addicted to flying, in company with rove-beetles, over flowers and middens on hot summer evenings. The latter is familiar to everyone. Perhaps its most arresting feature is the pair of nippers or forceps at the end of the abdomen. Microscopic examination of the embryo before it leaves the egg has shown that these are a modification of the jointed cerci, which many other insects possess. In the case of the common earwig, at least, the forceps play a part in the folding of the wings; but there is reason for thinking that they may also serve some other purpose at present unknown. The fore-wings (called tegmina[5]) are small, almost rectangular, and leathery in texture; but the hind-wings are broad and delicate. Each consists of a firm basal portion, and a relatively large membranous area, which is supported by numerous radiating veins or nervures.

[1] *Anurida maritima.*
[2] *Forficulidæ.*
[3] *Labia minor.*
[4] *Forficula auricularia.*
[5] The leathery fore-wings of earwigs, cockroaches, etc., are usually termed tegmina, as distinct from the hardened elytra (or wing-cases) of beetles.

The mode of folding the wings is very complicated, and is well described by Mr. O. H. Latter in the following passage: "The lower radiating veins first come together, creasing the delicate membrane between them fanwise; a cross fold is then made rather near the basal hard part, and is followed by a second cross fold in the reverse direction close to a line of dilated spots on the divergent veins; a contraction then occurs close to the base, so that the whole folded structure is compressed, the softer parts passing below the hard; and, finally, the abdomen is turned up and the nippers at its end employed to push all snugly 'home.'"[1] A small portion of each folded wing, however, always projects a little beyond its tegmen or cover. The common earwig, being mainly nocturnal in habit, is rarely seen in flight; but, by using a small camel's-hair brush and the blunt end of a fine needle, the wing of a newly-dead specimen can be unfolded without much difficulty.

The male of the common earwig has nine evident abdominal segments, the female only seven, though in each case the actual number is ten. The forceps of the sexes also differ—those of the male being strongly curved and toothed at their bases, while those of the female are almost straight, without teeth, and cross at the tips. The female has no ovipositor. She lays her eggs in the soil, and watches over them until they hatch, collecting them again into a heap if they should chance to be scattered. It has also been stated that she carries them about from one place to another in order that they may be exposed constantly to the conditions most favourable to their development, and that she fosters the young during the early stages of their

1 "Natural History of Common Animals."

growth. On these points, however, the evidence is somewhat conflicting. The young earwigs are hatched in the spring. They undergo several moults, and attain maturity in the late summer of the same year. They have no wings at first, but otherwise resemble the adults in general form. Thus, it is often said that there is no metamorphosis; but, in view of the fact that the attainment of wings as growth proceeds constitutes in itself a notable change, we shall probably be nearer the mark if we state that metamorphosis is slight. Earwigs have mouth-parts of the ordinary biting type, and are omnivorous, destroying snails, slugs, small caterpillars, and pupæ, but also doing considerable damage in gardens by feeding on the petals of flowers, leaves, and fruit—wall fruit being especially liable to attack.

The name "earwig" calls for a word of explanation. It appears to have originated in the widespread belief that earwigs enter the ears of sleepers, and even penetrate the brain. In almost all European countries the popular name of these insects has reference to the same supposed habit. Little evidence exists to support the theory, although Mr. Latter tells me that he once heard of a case in which an earwig did enter the ear of a child, and caused some inconvenience before it could be dislodged. Perchance when mankind, in his barbarian days, slept prone upon the ground in a cave or beneath the shelter of an overhanging rock, earwigs were more apt to take refuge in his ears than is the case to-day.

The third order of insects, termed Orthoptera, is represented in Britain by the cockroaches, grasshoppers, and crickets. All these insects have biting mouth-parts of the usual type. The fore-wings (teg-

mina) are relatively narrow and much thickened, serving as covers for the larger, more delicate hind-wings, which fold up like a fan. Orthoptera may be divided into two sections, according as they habitually walk or leap. Thus, in the cockroaches the hind-legs are used for walking or running, and do not differ greatly from the other legs in appearance; but in the grasshoppers and crickets the hind-legs are very long, with their femora often greatly thickened, and the insect usually progresses by a series of leaps. The young of Orthoptera (like those of earwigs) closely re-emble their parents, save in size and in the absence of functional wings.

The most familiar example of the running, or cursorial, Orthoptera—viz., the common cockroach,[1] or "black-beetle," of our kitchens—is not indigenous, but an immigrant from the East. It is practically cosmopolitan in its range, having been carried from one country to another by shipping. The male is capable of flight, but the wings of the female are reduced to small, movable plates, which reach back only to the third segment of the thorax. Like many of its near relatives, this insect is nocturnal in habit, and hides by day in dark crevices. It is nearly omnivorous, and in captivity feeds readily on its own weaker brethren, although when choice is possible it appears to favour a vegetarian diet. Onion is a coveted dainty, and is said to be one of the best baits for a "black-beetle" trap.

Our native species of the cockroach family,[2] three in number, all belong to the genus *Ectobia*. They are much smaller than their domesticated relative, and are not found in houses. The commonest seems to be the

[1] *Blatta orientalis.* [2] *Blattidæ.*

dark, almost blackish, *E. lapponica*, which lives in shrubs, nettles, or under moss and dead leaves. It may sometimes be seen in great number, the males flying actively in the sunshine from one point of vantage to another. A testaceous or greyish species[1] has a special liking for sandy districts, especially near the coast. The third species[2] appears to be somewhat rare, but has been captured in several English counties, including Surrey and Hampshire. It is pale straw-colour, with a reddish tint on the pronotum —*i.e.*, the dorsal plate of the prothorax, which in cockroaches is a prominent feature, especially in the winged adults, being usually round, and often projecting considerably over the sides and head. In *E. livida* both sexes can fly, but in the other two species of the genus the wings of the females are rudimentary.

Female cockroaches have no ovipositors. They lay their eggs in protective cases, or capsules, which vary in size and form according to the species. The egg capsule of the common cockroach is bean-shaped, dark mahogany coloured, with a fluted ridge along the dorsal side. It contains sixteen eggs, arranged in two parallel rows, and is carried about protruding from the posterior end of the female's body until a suitable hiding-place for it is found. After hatching, the young cockroaches push against the sides of the capsule, thus opening a slit along the dorsal ridge, through which they escape. The duration of the common cockroach's life, and the number of its moults, are points which have not yet been definitely established. Some observers have stated that maturity is not reached until the fourth year, and that the life of the individual may extend to five years. In the case of

[1] *E. panzeri.* [2] *E. livida.*

some other cockroaches, however, development is known to be much more rapid, being complete in the course of a few months.

Besides *Blatta orientalis*, at least six other exotic cockroaches occur in Britain, two having established flourishing colonies in several localities, though always within the shelter of buildings. One of these is the German cockroach,[1] which is a wild, woodland species in many parts of Europe and a household pest in Germany and France. The other is the American cockroach,[2] whose real home is said to be South America, although it has spread with commerce, and is now found in most parts of the world. Both these species are numerous in many warehouses, restaurants, and hotels, especially in London, and in some of the houses at the Zoological Gardens in Regent's Park. The former is rather small (about five-eighths of an inch from head to tail), reddish-testaceous in colour, with two dark, longitudinal marks on the pronotum. The latter is a handsome, chestnut brown insect, one inch and a quarter or more in length. In each species both sexes have fully-developed wings.

The leaping, or saltatorial, section of the Orthoptera comprises the short-horned grasshoppers,[3] the long-horned or tree-grasshoppers,[4] and the crickets.[5] In addition to the great development of their hind-legs, many of these insects are characterized by remarkable auditory structures, or "ears," while the males usually possess stridulating organs, by means of which they are able to produce "chirping" sounds. The females are equipped with ovipositors, which

[1] *Phyllodromia germanica.* [2] *Periplaneta americana.*
[3] *Locustidæ*—the *Acrididæ* of some authors.
[4] *Phasgonuridæ.* [5] *Gryllidæ.*

(except in short-horned grasshoppers) are often very conspicuous, projecting far beyond the extremity of the abdomen.

Short-horned grasshoppers may be recognized by their relatively short antennæ (composed of not more than thirty joints) and four-jointed tarsi. Their auditory structures are situated one on each side of the first abdominal segment, immediately above the articulation of the hind-leg. Each consists of a tympanum, or "drum," with a complex arrangement of nerve, muscles, and tracheal tubes. The tympanum may be visible externally as a rimmed depression, or it may be more or less roofed over, so to speak, so that one only sees a broad slit with a cavity beneath. The males stridulate by rubbing the femora of the hind-legs against the tegmina or fore-wings. If we examine with a strong magnifying lens the hind-leg of a male grasshopper, we shall find on the inner side of the femur a ridge, carrying a row of minute tubercles. This is the bow with which the little musician fiddles upon a prominent vein of the fore-wing, thus producing a shrill sound. It is an interesting fact that the "song" varies in different species, and an expert is often able to tell, merely by listening, what kind of grasshopper is making merry in a given spot. The female grasshoppers appear not to have stridulating organs, although they have well-developed "ears." This lends support to the belief now held by many naturalists that the chirping of the male is a kind of courtship accomplishment, calculated to excite amorous propensities in members of the opposite sex. The ovipositors of female short-horned grasshoppers are inconspicuous. The eggs are laid in the soil, a number being deposited in one hole together with a quantity of fluid which

ultimately hardens, forming a protective capsule. All the *Locustidæ* are exclusively vegetable feeders. Some fifteen species occur in Britain, if we include the stray locusts[1] which occasionally visit us. Only the common field grasshoppers, however, are truly indigenous. These fall into three genera—viz., *Stenobothrus*, *Gomphocerus*, and *Tettix*. The last includes two species, which may be known at once by the curious extension of the pronotum backwards over the abdomen. In *T. subulatus* the wings are long and the pronotum is nearly flat, while *T. bipunctatus* has short wings and the pronotum highly arched. The latter species, which appears to be the more common, frequents dry clearings in woods, where it hides amongst dead leaves. It lays its eggs in spring, hibernates during the cold weather, and may be found by searching all the year round. The genera *Stenobothrus* (six species) and *Gomphocerus* (three species) include the well-known "meadow grasshoppers," members of the former being distinguished by their thread-like, tapering antennæ, while those of the latter have the antennæ club-shaped. The species of *Stenobothrus* are distinguished by minute characters which cannot be dealt with here. Probably the three commonest species are *S. viridulus*, *S. parallelus*, and *S. bicolor*, all of which may be found on almost any grassy spot throughout the summer. *Gomphocera rufus* is reddish in colour, as its specific name implies. It frequents dry, grassy places, especially upon hillsides. *G. maculatus*, which occurs in sandy districts, may be recognized by its spotted appearance. *G. sibiricus* is really a mountain insect, and is included in the British list on the strength of a solitary specimen which is said to have

[1] So far as is known, these large species do not stridulate.

been captured on the hills near Netley, in Oxfordshire.

Owing to an unfortunate dissension among naturalists as to the original application of the name *Locustidæ*, it is used by many authors to designate the long-horned or tree-grasshoppers, although the family includes none of the locusts of common parlance. To escape from this dilemma, we shall in these pages follow the lead of those authorities who call locusts (including their lesser relatives the short-horned grasshoppers) *Locustidæ*, and the long-horned group *Phasgonuridæ*. It may be noted that this course has been adopted by those responsible for the arrangement of the Insect Gallery at the British Museum (Natural History). Members of the *Phasgonuridæ* may be easily recognized by their long, thread-like antennæ and four-jointed tarsi. The females have conspicuous ovipositors. In both sexes the external openings of the "ears" are at the bases of the front tibiæ, just below their articulation with the femora; while the males stridulate by rubbing a file-like vein, situated on the underside of the fore-wing or tegmen, over a sharp ridge on the upper surface of the tegmen lying beneath, the left tegmen being the file-bearing uppermost one. Furthermore, the right tegmen has at its base a drum-like vibrating membrane, while there is a corresponding cell or chamber on the underside of the left tegmen, the whole forming a kind of resounding apparatus. Long-horned grasshoppers frequent trees, shrubs, and herbage, and appear rarely to sit actually upon the ground. Their food consists of leaves to some extent, but most, if not all, of the species are largely carnivorous, eating caterpillars and other insects, and in captivity devouring one another with

apparent relish. The adults appear at the end of July, and in autumn lay their eggs in the earth, in crevices of bark, or in the pithy stems of plants. The young hatch in the late spring, and undergo about six moults before reaching maturity.

There are nine indigenous British *Phasgonuridæ*, but only three of the commoner species can be mentioned here. *Meconema varium*, a graceful insect, pale green in colour, with a yellow dorsal stripe, lives on trees, especially oak and lime, and may be shaken from the foliage in late summer and autumn. The "great green grasshopper"[1] is a much larger species—in fact, the largest of all. Its colour is deep green, often with reddish and dark markings. It dwells among nettles and coarse herbage, and is fairly common in the south, particularly near the coast. The "bush cheep,"[2] which is brown with black markings, occurs among brambles and bushes, often in hedgerows. It may be heard chirping on fine summer evenings, and has the habit of continuing its music late into the night.

The crickets[3] resemble the long-horned grasshoppers in many respects, but may be distinguished readily by their three-jointed tarsi. The female's ovipositor, when evident, is straight—not curved upwards, as in the preceding family. Moreover, the males have a stridulating file on the underside of *each* tegmen, while the right tegmen is usually folded above the left—not left above right, as with the long-horns. Crickets are practically omnivorous, and will eat worms, small insects, etc., in addition to leaves, roots, and other vegetable food. There are four British species. Of these the wood-cricket[4] is the

[1] *Locusta viridissima.*
[2] *Thamnotrizon cinereus.*
[3] *Gryllidæ.*
[4] *Nemobius sylvestris.*

smallest and rarest. It appears to be confined in this country to the New Forest district, where it dwells among dead leaves on dry banks. The house-cricket[1] is supposed to be a native of North Africa, where it is found in a wild state; but it has established itself in the dwellings of man in all parts of Europe, living always in the neighbourhood of the hearth or the oven. It is, however, far less common in England than was formerly the case, and Mr. Latter has suggested that it may be in process of extermination by the common cockroach. The field-cricket[2] is much larger than its domestic relative, almost black in colour, with a yellow patch at the bases of the tegmina. It forms burrows in dry, sandy spots which are exposed to the sun; but although common in many parts of Europe, in England is confined to a few isolated localities. This is the insect of which the naturalist Bates wrote: "The male has been observed to place itself in the evening at the entrance of its burrow, and stridulate until a female approaches, when the louder notes are succeeded by a more subdued tone, whilst the successful musician caresses with his antennæ the mate he has won." It seems a pity to mar the effect of this pleasing picture by stating that all crickets are inveterate fighters, and that in China the males are pitted one against another for sport. Last, but by no means least in point of interest, is the mole-cricket,[3] a large and curiously shaped species that was never common in England, and has apparently disappeared in recent years from several localities where it was once found. The fore-leg of the mole-cricket is very remarkable, being

[1] *Gryllus domesticus.* [2] *Gryllus campestris.*
[3] *Gryllotalpa vulgaris.*

adapted for burrowing. The short, broad tibia has prong-like projections below, which serve as a kind of rake, while two joints of the tarsus are furnished with hard processes, which can be moved back and forth over the tibial prongs, thus acting as shears for cutting roots which may impede the insect's progress through the soil. The female has no projecting ovipositor, but the number of evident abdominal segments in this sex is only seven, compared with nine in the male. Mole-crickets dwell in extensive subterranean burrows which they construct, and are seldom seen above ground. They usually frequent damp places, near to water. Gilbert White, the Selborne naturalist, gives a word-picture of this insect's home-life and habits that would be hard to beat. "A gardener at a house where I was on a visit," he writes, "happening to be mowing, on the 6th of May, by the side of a canal, his scythe struck too deep, pared off a large piece of turf, and laid open to view a curious scene of domestic economy. There were many caverns and winding passages, leading to a kind of chamber, neatly smoothed and rounded, and about the size of an ordinary snuff-box. Within this secret nursery was deposited nearly a hundred eggs of a dirty yellow colour, and enveloped in a tough skin, but too lately extruded to contain any rudiments of young, being full of a viscous substance. The eggs lay but shallow, and within the influence of the sun, just under a little heap of fresh mould, like that which is raised by ants." Like earwigs, mole-crickets watch over their eggs, and are said to care for their young during the early stages of their development.

CHAPTER III

STONE-FLIES, BOOK-LICE, MAY-FLIES, AND DRAGON-FLIES

WE now come to the fourth order of insects, the Plecoptera, which comprises the stone-flies.[1] They have biting mouth-parts, and two pairs of wings, which are alike in texture, with a complex network of veins, the hind-wings being much the larger. When closed, all the wings lie flat upon the back, and overlap, so that only one fore-wing is seen; while the front, or costal, portion of each fore-wing is turned downwards, thus covering and protecting the sides of the body. In many male stone-flies, however, the wings are so much reduced that they are useless for flight. The antennæ are long, many jointed, and slender, and there are usually two long cerci at the extremity of the abdomen, so that the insect appears to have a pair of antennæ at each end.

The manner of growth and development differs little from that which we have already seen in the case of the earwig or the cockroach. Except for the absence of wings, the young stone-fly closely resembles its parents in form; but its surroundings are very different, for it lives in rapidly flowing streams. Although it is able to swim well with its legs, it seldom employs this means of progress, preferring to

[1] *Perlidæ*.

creep stealthily about among the stones at the bottom. Some stone-fly nymphs are said to feed on decayed vegetation, but the majority are carnivorous, their chief prey consisting of the young of May-flies, or other small, soft creatures.

Clearly, the stone-fly nymph, being constantly submerged, cannot breathe through open spiracles after the manner of insects which dwell in the air. Nevertheless, it has the ordinary system of ramifying tracheæ. But the main trunks are connected with tufted, hollow gill-filaments, twelve groups of which may be found beneath the thorax, while there are little tufts of thread-like gills at the end of the abdomen, between the cerci. Through the delicate cuticle of the gills the air dissolved in the water is absorbed into the tracheæ, though the precise manner of this gaseous exchange is imperfectly understood. Some stone-fly nymphs have no gills, and appear to breathe through the integument, or outer skin, at points below which the main trunks of the tracheæ converge.

The change from the nymphal to the adult state is effected without a break in the creature's activity. When full-grown, the nymph, whose wing rudiments have become more and more obvious with each succeeding moult, simply crawls out of the water, and climbs up some convenient reed or twig. Its skin then splits down the back for the last time, and the perfect insect emerges. After a short interval, the wings attain their full size. Moreover, the spiracles are now open; but it is a curious fact that most, if not all, species of stone-fly retain the shrivelled vestiges of gills beneath the thorax throughout their winged life. Adult stone-flies frequent trees, and although very

MAY-FLY
(Ephemera)

DRAGON-FLY
(Calopteryx)

TIP OF DRAGON-FLY NYMPH'S "MASK"

DRAGON-FLY NYMPH WITH "MASK" EXTENDED

active, seldom stray far from the water whence they came. About twenty-four British species are known, but as they are all dull-coloured, they fail to attract the notice of the amateur naturalist. Perhaps the best-known species is *Perla bicaudata*, which is esteemed by anglers as a good bait for trout.

The fifth order of insects, the Corrodentia, includes a number of small species which are especially interesting because they are probably more nearly related to the termites, or "white ants," of the tropics than to any other insects. Mandibles are well developed, but the other mouth-parts have sustained considerable modification. When present, the delicate membranous wings have few veins; but many species (all in the second sub-order) are wingless. In all cases metamorphosis is slight. Probably the most familiar representative of the Corrodentia is the so-called "book-louse,"[1] which is common in many houses. In the house at present occupied by the writer this insect is very abundant, and is especially attached to a particular tiled washstand, in the crevices of which it harbours. Although very minute—just visible to the naked eye—it has a pair of stout little mandibles, and is said to work havoc in libraries by gnawing the surface of paper, whence its name. It is certainly destructive to collections of dried plants and insects unless measures for its suppression are adopted. Its maxillæ and labium are remarkable, the latter being thick and fleshy, while each of the former carries a hard, elongate process called a "pick," but what end these peculiar structures serve is not known. The "book-louse" shares with certain beetles the title of "death-watch," because it is supposed to produce a

[1] *Atropos divinatoria.*

regular tapping noise by knocking its jaws or head against woodwork. Whether this is indeed the case remains an open question, although several competent observers attest it as a fact. One or two other wingless forms of Corrodentia are sometimes found in houses, while certain winged species are very common out of doors. The latter frequent the trunks and branches of trees—some kinds preferring dead wood—and feed on lichens and fungi. Numbers of these tiny creatures may be captured during the summer months by the simple process of shaking a branch over a sheet of paper.

The "book-lice" and their near relatives[1] make up the sub-order Copeognatha of the Corrodentia. The second sub-order[2] comprises the remarkable parasites commonly called "bird-lice." These insects, which must not be confused with their repulsive blood-sucking namesakes mentioned in a succeeding chapter (p. 54), feed on the delicate parts of the feathers or hairs, and the dried secretions of the skin, of their "host." Most of the species live among the feathers of birds, but a few are found upon mammals. One[3] occurs upon dogs. These Mallophaga have relatively large, hard heads and flattened bodies, while their mouth-parts are lodged in a special cavity. Many kinds lay strangely shaped and beautiful eggs, which are much in demand as objects for the microscope.

The sixth order of British insects—viz., Ephemeroptera—has been constituted for the benefit of the May-flies,[4] whose relationship to other insects remains very obscure. In adult May-flies the mouth-parts are abortive or obsolete, while the digestive track is also

[1] *Psocidæ*.
[2] Mallophaga.
[3] *Trichodectes latus*.
[4] *Ephemeridæ*.

greatly reduced and quite functionless, no food being taken. Thus the final stage of the May-fly's life-history is little more than an expedient to secure the perpetuation of the species. The wings, which are traversed by a complex network of veins, are not folded when at rest, but are brought together and held erect above the back. The fore-wings are much larger than the hind-wings—the latter, indeed, being quite absent in some species. The antennæ are short and inconspicuous, but the fore-legs are often very long, and are extended beyond the head in a manner suggestive of "feelers." The hindmost segment of the abdomen bears at least two, often three, long thread-like cerci. The eyes of adult May-flies are remarkably developed, especially in the males. The compound eyes of this sex in certain species are divided, so that each part becomes virtually a separate organ—one portion being supported upon a kind of horn or pillar, while the other occupies a more usual position at the side of the head. Male May-flies appear to rely chiefly upon sight to secure mates during their brief twilight dances.

So far as the writer is aware, the complete life-story of a May-fly, from egg to imago, has not yet been told. It is known, however, that the eggs are dropped into the water by the female, and that the early stages of development extend over a considerable period, in some species perhaps as much as three years. The nymphs vary greatly in form according to their habits, but are always very unlike their parents, being relatively robust, with well developed mandibulate mouth-parts. They are entirely aquatic, and for the most part feed on water-weeds, though some also devour creatures smaller and weaker than themselves. Breath-

ing is effected by means of thread-like or leaf-like gills, within which the tracheal tubes ramify. These are not found on the thorax, as in the case of the stone-fly nymph, but are arranged in pairs at the sides of the abdominal segments.

Albeit the young May-fly differs widely in appearance from its adult form, its metamorphosis is incomplete, no quiescent or pupal stage being assumed. When the nymph is full grown, it creeps out of the water, its skin splits down the back, and the winged insect appears. But the transformation is not yet complete, for May-flies undergo their final moult after they have acquired the use of their wings. The insect which emerges from the split skin of the full-grown nymph is dull in hue, and seems, so to speak, to lack polish. It is, in fact, enveloped in a delicate skin, which is cast off either immediately or in the course of several hours. Thereafter the insect appears in its true colours, having reached its perfect state.

There are about forty British May-flies, some being very small. One of the commonest is *Ephemera vulgata*, known to anglers as the "grey drake."

The seventh order of insects comprises the dragon-flies, and is called Odonata. Its members possess so many distinctive features that they are unlikely to be confused with any other British insects. The large head, which is strongly concave behind, is attached to the thorax by a slender and remarkably mobile "neck," and can thus be turned readily from side to side, enabling the creature to make good use of its huge compound eyes. Dragon-flies depend almost exclusively upon their keenness of vision when hunting their insect prey, which they chase and capture

in mid-air. Possibly this accounts for the smallness of the antennæ, which—if we may judge by their size and structure—can be of little service as sense-organs; for in insects whose food-getting and other activities are known to be largely governed by smell the antennæ are usually markedly developed. The mouth-parts of a dragon-fly are of the biting type, the mandibles being exceptionally large and powerful; but both pairs of maxillæ are greatly flattened and otherwise modified, forming, in conjunction with the broad upper lip or labrum, a trap for seizing and holding the prey. Another peculiarity of the dragon-fly is the arrangement of its thoracic segments, more especially the meso- and metathorax. These, when viewed laterally, are seen to slope forward in such a way that while the wings are carried backwards all the six legs are brought close together under the mouth, where they serve as a kind of basket for holding the prey while it is being devoured. If a fly be offered to a captive dragon-fly, it uses its legs to seize the victim, but the capture is probably effected by the mouth-parts when the insect is flying freely in the air. All dragon-flies have four wings, which are glassy in texture, and traversed by a complex network of veins. Each is actuated by powerful muscles, and can be moved separately; while the very long abdomen supplies unique facilities for steering. It is said that the larger dragon-flies sometimes fly backwards, but this assertion still calls for verification. Nevertheless, their powers of flight, especially where rapid manœuvring is concerned, surpass those of any other insect. The general resemblance of a dragon-fly to a man-made aeroplane is not without significance.

The female dragon-fly (according to her kind) either

drops her eggs at random into a pool or lake, or boldly enters the water in order to lay them upon the submerged stems of water-plants, or in the mud at the bottom. The nymphs are quite unlike their parents; but although those of the various species differ among themselves in details of colour and form, they all possess certain peculiarities which render them unmistakable. The most characteristic feature is called the "mask"—really an elaborate modification of the second maxillæ, or labium. The contrivance is described by Mr. W. J. Lucas as follows: "The base is attached below the mouth; the hinder half lies under the head and fore-part of the thorax; there is a joint in the middle, and the fore-part lies under the hinder, bringing the base and tip together close to the mouth."[1] This is the position of the mask when at rest. But it can be shot out with great rapidity, in much the same way that a pugilist delivers a "blow from the shoulder." Moreover, the tip of the mask carries a pair of sharp, movable hooks (which are really the modified labial palpi), by means of which the nymph is able to seize any small animal that is unlucky enough to come within range. When a capture has been made, the mask folds back, bringing the victim to the mandibles and first maxillæ. A glance at the photograph reproduced on Plate IV. will help the reader to appreciate the manner in which the mask works.

Dragon-fly nymphs vary in colour from bright green through yellowish-green to brown, or almost black. Indeed, individuals of the same species often differ greatly in tint; and it is said that the coloration depends almost entirely upon the environment, and is

[1] "British Dragon-Flies."

adaptable thereto, so that the same nymph may be brown when lying on mud, but green later if it should come to rest among weeds. This chameleon-like faculty, as Mr. Lucas remarks, "no doubt serves a double purpose, that of hiding the nymph from its enemies, and at the same time enabling it, without being suspected, to approach within striking distance of its prey." In fact, the nymph has none of the activity which distinguishes its parents. Usually, it either waits for its victim to draw near, or else creeps stealthily towards it; though it can, on occasion, dart forward with considerable rapidity, propelling itself by means of a jet of water expelled from the anal opening, or (in some species) with the aid of three oar-like blades which project from the extremity of the abdomen. The food of the dragon-fly nymph consists of almost any aquatic creatures with which it may be strong enough to cope. Some of the larger kinds even attack small fish.

Young dragon-fly nymphs breathe in one of two ways. In most of the larger and heavier species, the rectum, or hinder portion of the intestine, is lined with gill-like folds, which receive fine branches from the tracheal tubes. Water is constantly drawn in and expelled through the anus, and the dissolved oxygen which it carries passes through the delicate cuticle of the gill-folds into the tracheal system. It is by the forcible expulsion of this water that these large nymphs are able to propel themselves forward. In the smaller and more slender species, the three oar-like plates at the tail-end are really gill-structures, traversed by air-tubes, by means of which gaseous exchange is effected. We have seen that these plates can also be used for propulsion when occasion demands. In all dragon-fly

nymphs, however, the thoracic spiracles are open during the latter stages of development, and the insect then obtains at least some of its oxygen by raising the front part of its body above the surface of the water. As the time for the final moult draws near, the now full grown nymph ceases to feed, and quits the water by climbing up some convenient stem or post. There is no definite pupal stage. The nymph remains passive for a brief period. Then its skin splits above the thorax, and the imago begins to extricate itself. When the head and thorax are free, the insect throws itself backward, and rests for about half an hour, supported by the hinder segments of the abdomen, which remain in the nymphal skin. The meaning of this period of inactivity, as suggested by Mr. Latter, is probably that the legs are as yet too soft and feeble for use. When they have become dry and firm, the insect jerks itself upward, and grasps with them the upper part of the nymphal skin. With the purchase thus gained, it draws out its abdomen. Some hours must still elapse, however, before the wings have developed and become hard enough for flight, while the full colouring and sheen of the integuments are not gained until two or three days later. With respect to the dragon-fly's duration of life, Mr. Lucas remarks: "It used to be thought that some of the larger species required three years to reach the final stage. They may take as long when the food-supply is scanty, but in all probability it will be found that the majority complete the cycle of existence within the year, even if one or two of the small species have not a second emergence about September." The life of the imago appears seldom to exceed three months. The adults never hibernate after the manner of some other insects.

The Odonata fall into two well-marked groups, or sections. In the first of these[1] the hind-wings are usually broader than the fore-wings at the base, while both pairs of wings are retained in an extended position when the insect is at rest. Moreover, the compound eyes meet on the top of the head, except in the case of a somewhat rare species called *Gomphus vulgatissimus*. This section includes the large, rapidly flying dragon-flies to which the name "horse-stingers" is often applied—though, of course, they have no stings, nor are they connected in any way with horses. Some of the species fly to great distances, far from water, and are even known to migrate in swarms. Two well-known examples from this section are *Libellula depressa*, in which the abdomen is broad and much flattened, with a bright blue bloom in the case of the male; and *Æschna cyanea*, whose abdomen is very long in proportion to the rest of the body, and cylindrical in contour. The latter is one of several species which display numerous yellow, green, or blue spots, symmetrically arranged on a dark ground colour.

In the second section[2] all the wings are alike in shape, both pairs being equally narrow at the bases. When the insect is at rest, they are held more or less completely closed over the back. Further, the compound eyes, though large and prominent, do not meet on the top of the head. The dragon-flies of this section are more frailly built than their Anisopterid allies, and are much slower in flight. Some of the exotic forms rank among the most brilliantly coloured insects known, while several of our own species are very beautiful. The so-called

[1] Called Anisoptera. [2] Called Lygoptera.

"demoiselle," [1] which is common in the South, may be cited as an example. The male is bright metallic blue in colour, with red eyes, and a large patch of opaque blue in the centre of each wing. The female is metallic green, with yellowish, transparent wings.

In all, there are about forty species of British dragon-flies, but several of these are very rare.

[1] *Calopteryx splendens*.

CHAPTER IV

THRIPS, BUGS, APHIDES, AND SCALE INSECTS

THE minute creatures termed "thrips" make up the eighth order, or Thysanoptera, of British insects. They are also called "flower insects," because they abound in blossoms of many kinds, including those of wheat and other cereals. Their mouth-parts are intermediate between the biting and sucking type, some being modified to act as piercers, while in conjunction they form a kind of short proboscis, which, when not in use, lies in a cavity beneath the thorax. The most remarkable peculiarity of the mouth-parts, however, is that some of them are asymmetrical—*i.e.*, they differ on the two sides. When present, the wings are exceedingly narrow, with long hairs on one or both margins; but many species are wingless throughout life. The tarsi have one or two joints, and are provided with a bladder-like sucker between the claws. Compound eyes are always present, while in the winged species there are usually three ocelli also. The antennæ have from six to nine joints, and are never very long.

The young thrips closely resemble their parents in form, and have similar habits. The wings are developed outside the body, and are said to become visible after the third moult; but although the meta-

morphosis is incomplete, it is not accomplished without a break in the creature's activity. In the stage before the final change the nymph becomes sluggish (in some species inert) and takes no food. Its body, limbs, and wing-rudiments are enveloped in a thin skin, which is cast off prior to the assumption of the adult state. Thus, as Professor Carpenter has remarked, "the development of the Thysanoptera exhibits an interesting transition towards a true metamorphosis."[1]

About fifty species of thrips have been found in Britain. Most, if not all, of them suck the juices of plants, attacking chiefly the essential organs of flowers. In this way considerable damage is often done to cultivated crops. The pea and bean thrips,[2] known to farmers as the "black fly," is the subject of a leaflet issued by the Board of Agriculture and Fisheries. Another species[3] is harmful to wheat and other cereals.

Members of the ninth order of insects (the Hemiptera) have their mouth-parts definitely modified for piercing and sucking. The mandibles and first maxillæ are transformed into long, slender stylets, which work to and fro within a kind of grooved sheath (called the rostrum) which is formed by the union of the second maxillæ. The whole contrivance constitutes a lengthy proboscis, which, when not in use, lies directed backwards beneath the body. When one of the Hemiptera feeds, it first brings the tip of its rostrum into contact with the organism (plant or animal as the case may be) that it is about to attack. The sharp-pointed stylets are then driven into the tissues, and a stream of saliva is pumped down the rostrum into the wound. The saliva is believed to arrest coagulation of

[1] "Insects, their Structure and Life."
[2] *Thrips pisivora.* [3] *Thrips cerealium.*

the blood or sap, thus enabling the insect to take a prolonged draft without difficulty. The rostrum being a grooved sheath—not a perfect tube—we may assume that capillary attraction is the chief agent in raising the fluid to the mouth. There is reason for thinking that at least some of the carnivorous species plunge the whole proboscis into the tissues of their victims; but in plant-feeders the tip of the rostrum seems rarely, if ever, to penetrate the surface.

The head of an Hemipterous insect is usually triangular in shape, while the slender antennæ have from three to eight joints. The pronotum, or dorsal plate of the prothorax, is often markedly developed, in some instances being the most arresting feature of the whole insect. The order is divided into two sub-orders. The first[1] includes about 430 British species, all of which are unfortunately branded with the name "bug"—unfortunately, because many of them are graceful and attractive insects, often prettily coloured. It is true that the objectionable bed-bug[2] has a place in their ranks, but its well-known parasitic proclivities are exceptional.

The fore-wing of a bug (the name cannot be discarded) is usually more or less thickened and opaque at the base, but the apical area is transparent, like the hind-wing. When not in use, the wings are folded over one another, and lie flat upon the insect's back. A shield-like plate (the scutellum) is visible between the bases of the wings. It is the dorsal part, or mesonotum, of the second thoracic segment. Moreover, in this sub-order the head is not bent back beneath the body in such a way that its front part touches the coxæ of the fore-legs. Throughout

[1] Termed Heteroptera. [2] *Cimex lectularia.*

the sub-order metamorphosis is incomplete, the young never differing greatly from their parents, save in the absence of wings.

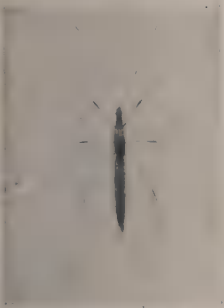
For the sake of convenience, the Heteroptera are usually divided into two series—viz.: (1) Gymnocerata, in which the antennæ are conspicuous, being held out in front of the head; and (2) Cryptocerata, in which the antennæ are very short, and concealed in cavities beneath the eyes. The former are typically "land bugs," though many forms dwell upon the surface of water; the latter are aquatic. Each section is divided into several families, among which the following may be mentioned:

The "shield-bugs"[1] are so called on account of the great development of the scutellum in most of the species. They may be represented by *Tropicoris rufipes*, a thick-set, brownish insect, with an orange spot at the apex of the scutellum. It is common upon trees and bushes in the autumn, and preys on caterpillars, whose juices it sucks. In similar situations may be found *Syromastes marginatus*, another brown species, with broad abdominal segments which project on each side beyond the folded wings. It is one of the family *Coreidæ*, whose members have the scutellum relatively small, and four-jointed antennæ which are club-shaped at the tip. These characters are shared by the *Berytidæ*, which may, however, be distinguished by their slender form and long legs. The antennæ are also very long, as may be seen in *Neides tipularius* (Plate V.). In the *Lygæidæ*, of which there are about sixty British species, the four-jointed antennæ are inserted lower on the head than in the *Coreidæ*. An example is *Nysius thymi*, a small bug

[1] *Pentatomidæ*.

SHIELD-BUG
(Tropicoris rufipes)

Ranatra linearis



Neides tipularius

Capsus laniarius

WATER-SCORPION
(Nepa cinerea)

named after the wild thyme, on which plant it is sometimes found.

In all the above-cited families the tarsi are three-jointed, but in *Tingididæ* they are two-jointed. These small bugs, of which there are about twenty indigenous species, are also distinguished for the remarkable sculpturing of the upper surface of the body, and of the fore-wings, while the scutellum is usually covered by the pronotum; *Monanthia cardui*, which may be found upon thistles during the autumn, and in moss during the winter and spring, may be instanced as an example. The *Aradidæ* also have four-jointed tarsi, but the scutellum is exposed and relatively large. Moreover, the members of this family are very flat, and are not attractively sculptured; *Aradus depressus*, which is not uncommon under loose bark, and in moss beneath old trees, is one of five British species.

The pond-skaters[1] live for the most part upon the surface of water, and feed on floating refuse or small aquatic creatures. Unlike most other bugs, their fore-wings are of one texture throughout. Their bodies and tarsi are covered beneath with a dense, velvet-like pubescence, which tends to repel moisture. The slender, long-legged *Hydrometra stagnorum* abounds among duck-weed, on ponds, from spring to autumn. Another common species, also with long legs, is *Gerris thoracica*. It is larger and more heavily built than *Hydrometra*.

The *Reduviidæ* are distinguished from the preceding families by the fact that the proboscis, when not in use, does not lie closely beneath the head. The family is abundantly represented in tropical countries, but the British species are not numerous. The

[1] *Hydrometridæ*.

largest[1] is occasionally found in houses, where it is said to prey on the bed-bug and other pests. When immature, it has the curious habit of covering itself with dust and débris. Several species of the genus *Nabis* are not uncommon among grass and herbage.

Members of the family *Capsidæ* have the wings large in proportion to the body. The antennæ are four-jointed, the second joint being usually very long. There are about 170 British species, most of which suck the juices of plants, though a few[2] are known to prey on other insects. They frequent plants of all kinds, and many of them are very active.

British water-bugs[3] are divided into four families. The *Nepidæ* are represented by two species—viz., the common water-scorpion,[4] and the rarer *Ranatra linearis*. The former is flat and thick-set, the latter long and slender. Both, however, have the fore-legs modified for capturing prey, while the abdomen carries two long, slender processes, which, when brought together, form a tube or syphon, through which air is conveyed to the tracheal system. Breathing is effected by thrusting the tip of the syphon through the surface-film into the atmosphere.

The *Naucoridæ* have four-jointed antennæ, and are especially characterized by having the fore-legs attached far forward on the prosternum. We have two indigenous species of these, *Naucoris cimicoides* (not unlike a small water-beetle in appearance) is common, whereas *Aphelocheirus æstivalis* is rare.

The only conspicuous British representative of the *Notonectidæ* is the familiar water-boatman,[5] though there is one other tiny species which lives in the mud

[1] *Reduvius personatus.* [2] *E.g., Capsus laniarius.*
[3] Series Cryptocerata. [4] *Nepa cinerea.* [5] *Notonecta glauca.*

at the bottom of shallow waters. The "boatman" swims on its back under water, and is very agile, using its long hind-legs with the skill of a practised sculler, but comes frequently to the surface to breathe and when submerged carries a supply of air entangled among the hairs of its body. Like all other water-bugs, *Notonecta* is carnivorous. It feeds on aquatic creatures, and is strong enough to master a good-sized minnow. A prick from its sucking beak is almost as painful as a bee's sting.

The *Corixidæ*, of which there are numerous British species, may be represented by *Corixa geoffroyi*. At first glance this insect might be confused with the water-boatman, but it may be known by the fact that the back of the head is not overlapped by the pronotum, as is the case in *Notonecta*. Both species have well-developed wings, and are thus able to fly from one pond or lake to another. Their habits are also similar, although *Corixa* seems to be more completely at home beneath the water, and comes less frequently to the surface.

The second sub-order of the Hemiptera includes the frog-hoppers, aphides, scale insects, and their allies. They are called Homoptera, and seem at first sight to be a rather mixed assemblage; but they agree in several important features. Unlike the Heteroptera, the front part of the head—the "face"—slopes strongly backwards, so that the mouth-parts, when not in use, are in contact with the coxæ of the fore-legs. Moreover, the fore-wings, though sometimes firmer in texture than the hind-wings, are never distinctly hardened at their bases; while, when in repose, the wings do not lie flat, but are held more or less roof-wise over the abdomen. In their life-

histories the Homoptera are evidently more advanced than the Heteroptera. The newly-hatched young are often very different from the parents, and may be regarded as true larvæ. Moreover, among the scale insects, the last moult is preceded by a definite pupa-like stage, when the creature remains quiescent, and takes no food. So far as is known, all the Homoptera feed on the juices of plants. The various families are often arranged in three series—viz., Trimera, Dimera, and Monomera—according to the usual number of tarsal joints.

The Trimera, or Homoptera with three-jointed tarsi, are divided into five families. Of these the cicadas,[1] so numerous in tropical countries, are represented in Britain by a single species. As a nymph it is said to feed at the roots of bracken. The adult is occasionally captured in the New Forest and elsewhere; but it is a great rarity. Members of the family *Membracidæ*, of which we have only two examples, may be at once recognized by the remarkable development of the pronotum, which extends backwards above the wings and abdomen. This is well shown in the photographs of *Centrotus cornutus* on Plate VI. The three remaining families of this series comprise numerous insects, mostly small, which are known collectively as "hoppers." The *Fulgoridæ*, which are related to the large, exotic "lantern-flies," are characterized by having their short three-jointed antennæ inserted *beneath* the eyes; whereas in the *Cercopidæ* the antennæ spring from *between* the eyes. In the latter family some of the nymphs protect themselves by a copious frothy secretion—the well-known "cuckoo-spit." The adults are known as

[1] *Cicadidæ*.

"CUCKOO-SPIT" INSECTS
(Philænus)

"CUCKOO-SPIT"

Centrotus cornutus
Much magnified

BROWN CURRANT SCALE
(Lecanium)

"frog-hoppers"; but this name also includes the *Iassidæ*, members of which may be distinguished by their triangular scutellum. In *Cercopidæ* the pronotum has an angular notch on the hind-margin. This receives part of the scutellum, which is accordingly rhomboidal in outline.

The series Dimera, whose members have two-jointed tarsi, comprises three families. The "green-fly," plant-lice, or aphides,[1] are so numerous and so harmful to all kinds of cultivated plants, that they are familiar to everyone; but certain facts connected with their increase and development are less well known. The life-cycle of a typical aphis may be briefly summarized as follows: Eggs are laid in the autumn on the twigs or bark of plants. From these, in the spring, larvæ hatch. They rapidly complete their metamorphosis, and when adult prove to be all females, vested with the remarkable faculty of parthenogenesis, or virgin reproduction. They are also viviparous—*i.e.*, they produce living young. Successive generations of these self-contained females appear throughout the summer, some being wingless, while others are winged, and thus able to fly from one plant to another. The last generation of the year comprises both males and oviparous females, the latter laying the eggs that are destined to start the next year's attack. These are the usual facts; but the complete life-cycle of some aphides extends over several years, and may include periodic migrations between two distinct kinds of plants. In fine, the life-stories of aphides are more complicated than those of any other insect, and many of them still call for elucidation. Some species, such as the well-

[1] *Aphidæ*.

known "woolly aphis" or "American blight,"[1] secrete a waxy substance in the form of delicate threads or flakes, and live beneath it. Others, of which the "currant-blister aphis"[2] may be instanced, give rise to galls (*i.e.*, abnormal growths) on leaves, stems, or roots. In all cases the infested plants are weakened by the continual sucking out of their sap; while in many instances the functioning of the leaves is arrested, owing to their stomata, or pores for gaseous exchange, being blocked by the sticky discharge of the insects. This substance, called "honey-dew," was formerly thought to be excreted through two tubes, or cornicles, which are situated on the backs of many aphides; but it is now known to issue from the anal opening of the alimentary canal.

The two remaining families of the series Dimera are the "jumping plant-lice"[3] and the "snow-flies."[4] The former have three ocelli (true aphides have none), and are further distinguished by their habit of jumping. The common apple-sucker[5] is often abundant in orchards, where it does much mischief. Adult snow-flies resemble tiny white moths, whose bodies and wings are covered with a fine powder or bloom. One species is sometimes found in enormous numbers on various kinds of cabbage, and when the plants are shaken, the insects rise and float in the air like miniature snowflakes — whence the popular name. The early stages of the life-history are peculiar, and have not been fully investigated. It is known, however, that the young insect secretes a scale, and that it remains beneath this protection, fixed to the underside of a leaf, until the metamorphosis is complete.

[1] *Schizoneura lanigera.* [2] *Rhopalosiphum ribis.*
[3] *Psyllidæ.* [4] *Aleurodidæ.* [5] *Psylla mali.*

The true scale insects[1] constitute the series Monomera of the Homoptera. They are minute insects whose tarsi have only one joint, terminating in a single claw. A common species is the mussel-scale,[2] which may often be found thickly encrusting the twigs of apple, hawthorn, and other trees and shrubs. If, in autumn, one of the larger scales be carefully lifted with the point of a needle, and examined under a lens, it will be found to contain the shrivelled body of the female insect, together with from 50 to 100 eggs. The newly hatched larva, which escapes from the scale in the spring, is an active, six-legged creature. It settles down upon a twig, from which it sucks the sap, and at the same time begins to secrete its scale. The latter grows with its owner, forming an effective shield or cover comparable to the shell of a limpet. The developing scale insect remains constantly in one spot, anchored by its proboscis. Indeed, the adult female—a grub-like creature, destitute of wings and legs—never leaves her scale at all. The male larva, however, becomes quite passive prior to its final moult, and assumes a state closely approaching to the true pupa of the higher orders. It is eventually transformed into a winged insect with long antennæ and well-developed legs; but only its fore-wings are functional, while its mouth-parts are reduced to mere useless vestiges. The males appear when the females are almost ready for oviposition; but they are rare, and parthenogenesis probably prevails. The family *Coccidæ* includes numerous species, which are attached to many kinds of plants. All do not form scales. The felted beech coccus,[3] for example, lives gregariously beneath a white, flossy substance, in the

[1] *Coccidæ*. [2] *Mytilaspis pomorum*. [3] *Cryptococcus fagi*.

secretion of which each member of the colony bears a part. Other species of the family are the brown scale,[1] and the cottony cushion scale,[2] both found on currant bushes, also the "mealy-bugs."[3]

For the sake of continuity, the loathsome creatures termed "lice" must be mentioned here. They constitute the tenth order of insects—the Anoplura—and are regarded by most authorities as degenerate allies of the Heteroptera; but their degradation—due, apparently, to long-continued parasitism—is so great that all obvious signs of relationship are obliterated. They may be defined as small, wingless insects, which spend their whole lives upon the bodies of mammals, whose blood they suck.

[1] *Lecanium.* [2] *Pulvinaria.* [3] *Dactylopius.*

CHAPTER V

ALDER-FLIES, SNAKE-FLIES, LACEWINGS, AND SCORPION-FLIES

THE eleventh order of British insects, or Neuroptera, used to consist of a very mixed company, ranging from stone-flies and dragon-flies to caddis-flies, and including a great variety of forms which differed greatly in their life-histories, and in many details of their structure. In fact, almost every tribe of insects that could not be fitted in conveniently elsewhere was marshalled with the Neuroptera. But modern naturalists, recognizing that relationship is the only sure guide to classification, are for the most part agreed that if a particular group of insects will not "fit in" with others, the safest plan is to rank it *pro tem.* as a separate order. With the growth of knowledge, and as "missing links" are discovered, it may become possible to connect many of these provisional orders with the larger divisions; but at present this is not feasible.

In its restricted form, the order Neuroptera includes the alder-flies, snake-flies, and lacewings, besides the interesting ant-lions and their allies, which, unfortunately, are not represented in Britain. In all these insects the mouth-parts are of the biting type. The antennæ are long, many-jointed, and slender. The adult has always four nearly similar wings traversed

perfect insect ultimately emerges. The life of the adult is short, being limited to a few days; but the precise duration of the complete life-history has not yet been ascertained—so far, at least, as the writer is aware.

The curious snake-flies[1] are easily recognizable in the perfect state, because of the remarkable development of the prothorax and the back of the head, which together form a kind of "neck." Indeed, the fore-part of the insect is very suggestive of a snake—whence the popular name. The female has a long, slender ovipositor, and appears to lay her eggs in old timber or under bark, for the larvæ are found in such places. They are active little creatures, which wriggle rapidly backwards when alarmed, and hunt their prey with the utmost voracity. Yet they are able to sustain long fasts, and we may infer from this that the duration of the life-history depends upon the abundance or scarcity of the food-supply, as is the case with some other insects. "The larva of the snake-fly," says Dr. Sharp, "changes to a pupa that is remarkably intermediate in form between the perfect insect and the larva; the eyes, legs, wing-pads, and ovipositor being but little different from those of the imago, while the general form is that of the larva, and the peculiar elongation of the neck of the imago is absent. This pupa differs from that of *Sialis* in the important particular that before undergoing its final ecdysis (or moult) it regains its activity, and is able to run about." The three or four British species of the genus *Raphidia* frequent wooded districts, and are said to be rare, though their apparent scarcity is probably due in large measure to their small size and retiring habits.

[1] *Raphidiidæ*.

Like many other supposed rarities, they can generally be found when searched for in suitable localities, due regard being paid to time and season.

We now come to two families whose members pass collectively under the popular name of "lacewings," because of the extremely complex and beautiful net-veining displayed by their wings. The first is known as *Hemerobiidæ*. It includes several British species, which may be distinguished by their moderately long antennæ, whose numerous joints, when magnified, resemble a string of beads. Two sub-families are recognized—viz., *Osmylinæ* (in which simple eyes are present), and *Hemerobiinæ* (in which simple eyes are absent). The *Osmylinæ* are represented by *Osmylus chrysops*, which is not uncommon in the New Forest, where its larvæ live under stones or among moss and weeds in damp situations, or actually in water. They have long, slender mandibles, or "sucking-spears," with which they pierce and empty the small insects upon which they prey. According to Dr. Sharp, the larva is hatched in the autumn and hibernates before it attains full growth. It is provided with silk glands and a spinning apparatus at the tail-end; and, prior to its assumption of the pupa state, it forms a small round cocoon of silk mixed with sand grains. The second sub-family[1] comprises rather small insects, some of which have a very moth-like appearance. The larvæ frequent plants and hunt aphides, which they suck dry. Some of them cover themselves with the empty skins of their victims, to which fragments of vegetable matter may be added, and thus go about bearing a load of débris by which they are often completely hidden from view. When full fed, the larva spins a cocoon.

[1] *Hemerobiinæ*.

Members of the second lacewing family[1] are often called "golden-eyes," owing to the peculiar metallic lustre of the eyes in the living insect. There are about fifteen British species, which may be distinguished from the *Hemerobiidæ* by their relatively longer antennæ, the joints of which are cylindrical, not bead-like. They are extremely delicate and beautiful insects, green or greenish-yellow in colour; but when handled they leave an unpleasant smell upon the fingers. Hence they have been dubbed with a third popular name—to wit, "stink-flies." Their eggs, which are fixed to the leaves and stems of plants, are very remarkable objects, each being supported upon an immensely long stalk. Dr. L. O. Howard, the great American entomologist, states that the larvæ are so voracious that the first one to hatch would eat up all the other eggs if the latter were laid side by side on the surface of a leaf in the more usual manner; but this explanation is open to criticism. The eggs of some species are found in compact clusters; but they appear more often to be laid singly—one here, another there. The newly hatched larva climbs down its egg-stalk and begins to hunt for the aphides on which it preys. It feeds in a peculiar manner, holding the victim high in the air with its long jaws until it has sucked the carcass dry. Some of these larvæ cover themselves with the skins of their victims; others use green algæ or fragments of moss or lichen for the same purpose; but the majority go unclothed. The tip of the abdomen is provided with a kind of sucker, which is used both as a lever to assist locomotion, and as an attachment by means of which the insect can hang from a leaf or twig. When

[1] *Chrysopidæ*.

its feeding is over, the larva spins a round cocoon, which appears strangely small when compared with its maker, or with the perfect insect which eventually emerges from it through a small hole, to which the cover remains attached like a lid. Judged from the economic standpoint, the Chrysopid lacewings are of considerable importance, for they are common insects, and their larvæ must destroy myriads of aphides or "green-fly" each season.

The last family of British Neuroptera is called *Coniopterygidæ*. They are all tiny insects, with antennæ much longer than the body. The wings have a very simple neuration, with few cross veins, while the hind-wings are much smaller than those of the front pair. Moreover, the body and wings are covered with a peculiar white bloom. The larvæ frequent plants, and resemble those of lacewings in their form and metamorphosis. They have been observed to feed on minute scale insects.

The twelfth order of British insects, the Mecaptera, consists of the scorpion-flies,[1] a family which used to be included with the Neuroptera. These insects display certain unique features in their structure and life-histories, and their relationship to other orders has not yet been demonstrated. The front part of the head is very long and narrow, forming a kind of beak, at the tip of which the small, toothed mandibles are inserted. The first maxillæ are considerably elongated, and bear five-jointed palpi; while the second maxillæ, which are not specially long, are completely fused to form the labium or lower lip. The antennæ are long, slender, and many-jointed. The four wings are narrow, traversed by many veins, and (in the com-

[1] *Panorpidæ*

mon British species) strikingly mottled with brown patches upon the transparent membrane. One species, however, is wingless. It is known as *Boreus hiemalis*, lives in moss and under stones, and has been variously likened to a "large flea" and a "minute wingless grasshopper." The length of the female, inclusive of her rather long ovipositor, is less than a quarter of an inch.

The winged scorpion-flies, which are not uncommon in woods, all belong to the genus *Panorpa*. In the males the tip of the abdomen is curiously modified, and is usually carried over the back like the tail of a scorpion—whence the popular name. Scorpion-flies undergo a complete metamorphosis, the larva being of the caterpillar type, but with the antennæ and eyes unusually prominent. They have three pairs of thoracic legs, and (except in *Boreus*) a pair of prolegs on each of the first eight abdominal segments. Their mandibles are not grooved for suction. These facts were first made known by the Austrian entomologist, Brauer, who induced scorpion-flies to deposit their eggs on damp earth in a covered vessel, and subsequently reared the larvæ. They spent most of their time burrowing in the earth beneath pieces of meat that had been provided for their food. In a wild state they are found near the surface of the soil, where they probably feed upon dead animals, especially insects. Brauer also found many larvæ of *Panorpa communis*, associated with ants, in a decayed tree-stump that was quite covered with moss. The larvæ are said to be active for about a month after hatching. Then they become quiescent, but do not change to the pupa for some weeks. The adults are also carnivorous, but they capture living insects.

CHAPTER VI

BEETLES

BEETLES (which make up the thirteenth orde of insects—viz., Coleoptera) may almost always be recognized by their thickened fore-wings, or elytra. These act as covers, beneath which the membranou hind-wings are folded when they are not in use. The mandibulate mouth-parts are not unlike those of the order Orthoptera, but the second maxillæ are ver intimately united. The dorsal plate of the firs thoracic segment (pronotum) is generally large, while a scutellum is often visible between the bases of th elytra. The legs vary greatly in shape, but the cox of the hind pair are almost always large and powerful.

Beetles undergo a complete metamorphosis. Thei life-stories are very varied, and the larvæ differ great in appearance, ranging from active creatures with a hardened cuticle, to soft, legless grubs. The wings are developed inwardly, and do not become visib until after the penultimate moult. The full-grown larva often constructs a cocoon. The pupa is "free" —*i.e.*, its appendages, though lying close to the bod are not immovably fixed thereto by a general harden ing and thickening of the outer skin.

This is probably the largest order of insect Upwards of 3,400 British species have been describe The classification of this vast army is far from com-

STAG-BEETLE, UNDERSIDE
(Lucanus)

TIMBERMAN-BEETLE
(Acanthocinus)

WATER-BEETLE
(Dytiscus)

GLOW-WORM BEETLE, MALE AND FEMALE
(Lampyris)

plete; for although it is almost always easy to distinguish a beetle from any other kind of insect, the details of beetle kinship—the branchings of their own family tree, so to speak—often prove very difficult to follow. For the purpose of this chapter we may review briefly the six great groups, or series, into which the order Coleoptera is divided by Dr. Sharp. Five of these are "natural" — *i.e.*, they denote actual relationship among the families concerned; but the sixth, which we shall treat last, is admittedly a kind of lumber-room to which numerous families have been relegated until their true standing can be ascertained.

The series Adephaga includes the tiger-beetles, ground-beetles, and carnivorous water-beetles, which have five-jointed tarsi, while the antennæ are simple in form, consisting of a series of nearly similar joints. The galea, or outer lobe, of each first maxilla is two-jointed, and resembles a palpus. The active larvæ have six well-developed legs, with two claws to each tarsus.

The tiger-beetles[1] may be represented by the common green *Cincindela campestris*, which frequents sandy spots during the early summer. The larva forms a perpendicular shaft in dry soil, and blocks the entrance with its head and thorax, supporting itself by means of a pair of hooks situated upon its fifth abdominal segment. When an insect approaches, the "tiger" throws back its head with a rapid jerk, seizes the victim with its sickle-shaped jaws, and drags it to the bottom of the burrow.

The ground-beetle family[2] comprises numerous British species, which are divided into several sub-families. The large violet ground-beetle[3] is a familiar

[1] *Cicindelidæ.* [2] *Carabidæ.* [3] *Carabus violaceus*

example. It is more heavily built than a tiger-beetle while its eyes are smaller and far less prominent. The little bombardier-beetle[1] must also be mentioned, because of its singular method of self-defence. It is preyed upon by larger members of the family, and when chased ejects a drop of volatile and explosive fluid from the tip of its abdomen, thus disconcerting its pursuer. Most ground-beetles and their larvæ are nocturnal in habit, and hide by day under stones or in crevices of the soil. The majority are predaceous, but there are a few remarkable exceptions, several species feeding on rootlets and seeds.

The carnivorous water-beetles[2] may be typified by *Dytiscus marginalis*, often called the "great water beetle." Its structure agrees very closely with that of a ground-beetle, but the details are beautifully adjusted to meet the requirements of a life that is spent chiefly in the water. The insect is an expert swimmer and diver, and preys exclusively on aquatic creatures. Nevertheless, it has well-developed wings, and frequently flies by night from one pond or lake to another. Its spiracles open beneath the elytra, the edges of which fit closely against the sides of the abdomen, enclosing an air-tight space above the back. This space serves as a reservoir for air. Moreover, the two posterior pairs of spiracles are uncommonly large, so that by thrusting its tail-end through the surface-film into the atmosphere, and slightly depressing the tip of its abdomen, the insect can rapidly discharge the vitiated air from its tracheal system and take in a fresh supply. The *Dytiscus* larva is extremely rapacious. Its mandibles are pointed and tubular, and it feeds by suction, after the manner of

[1] *Brachinus crepitans.* [2] *Dytiscidæ.*

a Neuropterous larva. It has only one pair of spiracles, situated at the extremity of the abdomen, where there are also two leaf-like appendages fringed with hairs, which help to support the larva when it is hanging head downwards from the surface in the act of taking breath. When full-fed it creeps out of the water, forms a cell in the earth, and therein changes to the pupa.

The series Lamellicornia comprises the stag-beetles, chafers, and their allies, which also have five-jointed tarsi. The terminal joints of the antennæ—three or more of them—are broadened on one side so as to form a curious club, which may be comb-like, or "lamellated"—*i.e.*, composed of flattened pieces like the slats of a Venetian blind. The larvæ feed in concealment on decaying wood, roots, vegetable refuse, or the droppings of animals. They have hard heads, with powerful mandibles, feeble legs, and soft curved bodies—the last two segments of the abdomen having the appearance of being swollen.

In the stag-beetle family[1] the antennæ are elbowed, and the mandibles of the males are often greatly enlarged, as is the case with our own *Lucanus cervus*. The great "horns" or "antlers" are really the insect's jaws, and are said to be used occasionally to nip fruit, etc., causing the juice to flow, so that it may be taken into the mouth by means of the maxillæ. They are also employed for other purposes, perhaps more important—*e.g.*, to hustle and drive away rival suitors at the period of courtship. The larvæ burrow into wood (especially oak), and feed for about three years before their growth is complete, eventually forming cocoons of chips or earth. The pupal period, which

[1] *Lucanidæ*.

is very short, is accomplished in the autumn, and the perfect insect remains quietly in the cocoon throughout the winter and spring, emerging in June or July of the succeeding year. We have two smaller species of *Lucanidæ* in Britain, but the mandibles of their males are not conspicuously developed.

The second Lamellicorn family[1] includes the chafers, dung-beetles, and rose-beetles. The most familiar example is the cockchafer, or "May-bug,"[2] a handsome insect, but unfortunately very destructive. The larvæ consume the roots of grass and cultivated crops, and the adults eat the leaves of oaks and other trees. The antennæ of the male exhibit the "lamellated" character in a marked degree, and are worthy of close examination. The clubbed part is composed of seven pieces, whereas in the female the corresponding, but much smaller, plates number only six.

The well-known rose-beetle[3] by no means confines itself to the flower whose name it bears, but attacks and devours the leaves and blossoms of many plants, including raspberries and strawberries, while it has been known to strip whole rows of broad beans and currant bushes. The larvæ occasionally devour living roots, but they seem usually to feed on decaying vegetable matter, and may often be found in heaps of leaf mould. They form compact, oval cocoons of earth or wood-chips before changing to the pupa. It is interesting to note that a closely allied rose-beetle[4] is found in ants' nests.

The dung-beetles[5] are of considerable economic importance. Probably the best known is the "dumble-

[1] *Scarabæidæ*.
[2] *Melolontha vulgaris*.
[3] *Cetonia aurata*.
[4] *C. floricola*.
[5] A sub-family of the *Scarabæidæ*.

dor,"[1] which may often be seen in strong but blundering flight, especially towards evening, during the late summer and autumn. In the allied *Typhæus vulgaris* the male has a very striking appearance, its thorax being armed with three stout, forward-directed horns. Both these species, and their allies, make burrows in the ground, and stock them with stercoraceous matter. In this way provision is made for the needs of the larvæ, an egg being laid by the female in each burrow. This group of insects comprises upwards of fifty species, most of them much smaller than the two that have been named. It constitutes no insignificant part of Nature's machinery for securing a rapid distribution of nitrogenous matter in the soil.

Members of the series Heteromera are distinguished from all other beetles by the fact that the tarsi of the front and middle pairs of legs are five-jointed, while those of the hind pair are four-jointed. One of the largest British species is the dull black *Blaps mucronata*, often called the "cellar" or "churchyard" beetle. Its hind-wings are rudimentary, and the elytra are united along their middle edges, thus serving not as "wing-covers," but as a kind of shield above the abdomen. The larva, which feeds on waste matter of various kinds, is not unlike a large meal-worm in appearance—being, in fact, nearly related. The meal-worm itself is too well known to need introduction; but many people express surprise when told that this pest is the youthful form of a beetle. Besides damaging meal and flour, this larva is one of several kinds which infest biscuits, rendering them "weevily." There are really two kinds of meal-worm beetles. One, called *Tenebrio molitor*, is probably indigenous;

[1] *Geotrupes stercorarius*.

the other, *T. obscurus*, is said to have been introduced with American flour.

Another well-known Heteromerous species is the scarlet cardinal-beetle,[1] a very active insect, which may often be seen flying in the hot sunshine. Its whitish larvæ, which are remarkably flat, are found under bark; but whether they feed on wood, or on other insects which frequent similar situations, the writer has not been able to discover. The adult beetle is notoriously rapacious.

The life-stories of the Heteromera are sometimes very complex. For example, the common oil-beetle[2] lays enormous numbers of eggs—perhaps as many as 10,000—on the off-chance, so to say, that a few of the newly-hatched larvæ may contrive to "get a lift" on the back of a bee. A lucky larva is thus carried home to the bee's nest, where it appears first to eat one of its host's eggs, and then to gorge itself with honey. The complete life-cycle involves an astonishing series of form-changes which cannot be described in detail here. Suffice it to say that the larva, after becoming a fat, curved grub of the Lamellicorn type, changes to a "false pupa." It then rests and takes no food; but a second period of activity follows before the true pupal stage is reached. The adult *Meloë* is found feeding on herbage in the springtime. It is nearly related to the beautiful green "blister-beetle," or "Spanish-fly,"[3] which is occasionally seen in the Southern Counties. Both these insects are protected from the attacks of birds, etc., by a caustic secretion which is extracted from their bodies and used medically under the name of cantharidine.

[1] *Pyrochroa coccinea.* [2] *Meloë proscarabæus.*
[3] *Lytta vesicatoria.*

In the series Phytophaga the tarsi of all the legs appear to be four-jointed, but close inspection reveals the presence of a very small fifth joint at the base of the fourth. The three basal joints of each tarsus are usually clothed beneath with a dense, velvety pile. The antennæ, which are composed of a series of simple joints, are generally rather long, sometimes very long. The Phytophaga feed, almost without exception, on vegetable substances, and may be divided into three families—viz., the seed-feeders,[1] the leaf-feeders,[2] and the wood- and stem-feeders.[3] The last are often called Longicornia, or "long-horns."

The *Bruchidæ*[4] may be represented by the common pea-seed-beetle,[5] whose grub feeds and pupates in a pea. The leaf-feeders[6] are mostly oval and convex in shape, often brightly coloured with a metal-like polish; but our largest species[7] is dull blue-black. It is known popularly as the "bloody-nose beetle," because, when irritated, it ejects a large drop of clear red fluid from the mouth. The pretty little *Chrysomela polita* (shining green thorax and legs, and red-brown elytra) is often abundant in grassy places, where also other species of the genus may be found. All Chrysomelid larvæ have well-developed thoracic legs, and feed openly on the foliage of plants. The poplar- and willow-leaf-beetle[8] occurs in all stages, from egg to perfect insect, on the trees whose names it bears, the pupa being attached by its tail to a leaf. This species, and the closely similar *M. longicollis*, sometimes cause serious damage in osier-beds, especially in the South of England.

[1] *Bruchidæ*. [2] *Chrysomelidæ*. [3] *Cerambycidæ*.
[4] Also called *Lariidæ*. [5] *Bruchus pisi*. [6] *Chrysomelidæ*.
[7] *Timarcha lævigata*. [8] *Melasoma tobuli*.

Other Chrysomelid species are the dainty little asparagus-beetle,[1] the much-dreaded Colorado-beetle, or "potato-bug,"[2] and the diminutive turnip and cabbage "fleas" of the genus *Phyllotreta*. Indeed, very many members of the family are highly injurious to cultivated crops. The attractively coloured, riverside beetles of the genus *Donacia* are, happily, free from this stigma. Their life-stories present some very unusual features. The larvæ feed on the submerged roots of aquatic plants. Their method of breathing is peculiar, for they have two sharp-pointed tubular processes near the tip of the abdomen, and by driving these into the air-spaces of the plant's tissues they contrive to extract sufficient oxygen for their needs. So far as the writer is aware, no other insects are known to *breathe* at the expense of their food-plants!

Before leaving the *Chrysomelidæ*, the curious tortoise-beetles of the genus *Cassida* must be mentioned. They and their allies constitute a very distinct group or sub-family. When at rest, the insect's body and its appendages are completely hidden beneath the pronotum and elytra, which are unusually broad and flat. The common *Cassida viridis*, found upon thistles, looks more like a small green blister on the stem or leaf than a living insect. The larvæ of this and other species have the strange habit of covering their bodies with their own dried excrement, the matter being held in place by a kind of fork, situated at the posterior extremity.

The Longicorns[3] may be easily recognized by their oblong form, long antennæ, and kidney-shaped eyes. The typical larvæ of the family have hard heads and

[1] *Crioceris asparagi*. [2] *Doryphora decemlineata*.
[3] *Cerambycidæ*.

powerful mandibles, and are either legless, or have only very small legs. Their bodies are soft and fleshy, white or yellowish-white in colour, broadest in front, and generally somewhat flattened. Most of them burrow in dead or decaying wood, but a few attack living stems. The full-fed larva usually constructs a cocoon of chips before changing to the pupa.

The majority of our indigenous Longicorns are rare, but three or four are sufficiently abundant to attract popular attention. One of these is the so-called wasp-beetle,[1] which frequents wild roses and other flowers during the early summer. Its coloration—black, with yellow bands—suggests that of a wasp, whence its name. The larvæ, which tunnel in decaying posts or the stumps of dead trees, take several years to attain full growth, and in conditions unfavourable to their development seem able to prolong their larval life almost indefinitely.

The poplar long-horn[2] places its eggs beneath the bark of young aspen twigs, within which the larvæ feed for nearly two years, each giving rise to a characteristic swelling, or "gall." The pine long-horn[3] is often abundant in fir woods, where on warm days in June it may be seen flying among the trees, or running over logs or dead trunks, beneath the bark of which the larvæ feed. The beautiful green musk-beetle[4] must also be mentioned. As its name suggests, it emits a pleasing odour that is sufficiently strong to be detected at some distance from trees (usually old, pollarded willows), in which it breeds. The most remarkable of all British long-horns, however, is the timberman-beetle,[5] which occurs at Rannoch, in Perthshire, and other

[1] *Clytus arietis.* [2] *Saperda populnea.* [3] *Rhagium bifasciatum.*
[4] *Aromia moschata.* [5] *Acanthocinus ædilis.*

localities in Scotland. It is conspicuous for the enormous length of the antennæ, especially in the male.

The series Rhynchophora comprises the beetles that are known popularly as weevils. They differ from all other Coleoptera in having four-jointed tarsi; or, rather, the tarsi *appear* to be four-jointed, though in reality a minute additional (or fifth) joint is present at the extreme base of the fourth. The head is elongated in front to form a beak or rostrum—sometimes short and thick, sometimes long, thin, and arched—which carries the mouth-parts at its apex. The larva is a legless grub, and usually forms a cocoon before changing to the pupa. Weevils feed exclusively on vegetable substances, and it has been said that there is no part of any plant, or its products, that their larvæ do not attack.

Most British weevils belong to the great family *Curculionidæ*. Their antennæ, which spring from the rostrum, are usually elbowed—*i.e.*, with a long, basal oint, to which the other joints are attached, like the thong of a whip. The nut-weevil[1] is notable for its immensely long and slender rostrum, by means of which the female bores holes in green nuts when they are very young, afterwards depositing an egg in each. The apple-blossom weevil[2] treats the flower-buds of the apple in a similar manner, and its larva feeds on the essential parts of the bloom, with the result that no apple is produced. The corn and rice weevils[3] are even more destructive in another sphere. They infest wheat, barley, rice, etc., have spread with commerce to all parts of the world, and have sometimes rendered almost valueless whole cargoes of grain which

[1] *Balaninus nucum.* [2] *Anthonomus pomorum.*
[3] *Calandra granaria* and *C. oryzæ.*

have been carried long distances in sailing ships. Cultivated plants of many kinds are attacked by members of the genus *Otiorhynchus* and their allies. The commonest species is *O. picipes*, known to gardeners as the "clay-coloured weevil." The larvæ attack roots, while the adults injure young, succulent shoots. Another genus[1] comprises numerous tiny species, all more or less pear-shaped in form. Most of them frequent leguminous plants, and several are harmful to the cultivated clovers, the weevils eating holes in the leaves, and laying their eggs in the seeds, which the larvæ destroy. In fine, the habits of very many Rhynchophora run counter to the interests of civilized mankind, and the whole series has thus fallen into serious disrepute. Nevertheless, it includes not a few species that are harmless—judged from the economic standpoint; and certain of these display instincts that are unsurpassed by any other beetles. For example, the female *Attelabus curculionoides*, at the expense of much labour, cuts and rolls oak-leaves into compact, thimble-shaped masses, in which she deposits her eggs. When hatched, the larvæ eat the inner part of the mass, but eventually allow themselves to fall to the ground, where they pupate and pass the winter. Other "leaf-rolling weevils" are found upon trees and shrubs of various kinds.

Another family of the Rhynchophora—viz., *Scolytidæ*—includes the so-called "bark-beetles." These are distinguished by having the rostrum extremely short, while the antennæ are also short, with a broad club. The females make tunnels between the bark and the wood of trees, and lay their eggs therein. From this "mother gallery," as it is called, the young grubs

[1] *Apion.*

burrow outwards, and in this way curious and characteristic patterns are traced upon the surface of the wood. Each grub pupates at the end of its burrow, and the perfect insect eventually bores a hole through the bark in order to effect its escape. One of the commonest species is the elm-bark-beetle.[1] Another is the pine-bark-beetle,[2] which does much damage in its perfect state by burrowing into the young shoots of the Scots pine—in order to feed, be it noted, since the eggs are laid beneath the bark in the manner described above.

The series Polymorpha now claims our attention. We have already seen that it can only be characterized by the fact that its members do not belong to any of the other five series. Only the more interesting and important families can be mentioned here.

The whirligig-beetles[3] are by some authors included with the Adephaga, but they differ greatly in structure, notably in having each compound eye divided into two. One isolated half of each eye is directed downwards, thus enabling the insect to search for its aquatic prey; the other half keeps watch above; for whirligig-beetles seldom enter the water, except to escape danger, but spend their days skimming rapidly over the surface. The larvæ, however, are completely aquatic, and breathe by means of abdominal gill-filaments, not unlike those of an alder-fly larva. When full grown, they leave the water and spin small papery cocoons upon the leaves and stems of plants.

Members of the family *Hydrophilidæ* may be recognized by their long maxillary palpi. Some of the species are completely aquatic, while others frequent marshy spots. The majority are quite small, but

[1] *Scolytus destructor.* [2] *Hylurgus piniperda.* [3] *Gyrinidæ.*

Hydrophilus piceus—the "harmless" water-beetle of the aquarium—is one of the largest British beetles. When submerged, this insect carries a kind of breast-plate of air, which is held in place by velvety tracts on the underside of the body. It replenishes this supply periodically by dragging down small air-bubbles with its antennæ, the terminal joints of which are broad and hairy, and serve as little scoops. Although the adults feed chiefly on vegetable matter, the larvæ attack other insects, and are very voracious.

The family *Silphidæ* includes more than one hundred British species, which vary considerably in size and form. They have straight, clubbed antennæ, which are usually composed of eleven joints. Most of them feed on decaying animal or vegetable matter. The sexton-, or burying-beetles, of the genus *Necrophorus* are familiar examples. So also are the flat-looking members of the genus *Silpha*, which are mostly carrion-feeders, though one or two species are known to eat the leaves of living plants.

In the great family of the rove-beetles, or "cock-tails,"[1] the elytra are very short, covering only a small part of the abdomen. The antennæ are moderately long, very gradually thickened towards the tip, and have usually eleven joints, but sometimes ten or even nine. The "devil's coach-horse"[2] is the best known example; but there are about 800 British species, most of them very small. Many fly freely, and cause annoyance during the summer months by getting into our eyes—when they are called "flies." The larvæ are very similar in appearance to those of ground-beetles, but may be distinguished by their one-clawed tarsi. Members of this family

[1] *Staphylinidæ*. [2] *Ocypus olens*.

usually feed on other insects, molluscs, or worms; but some species eat carrion or vegetable substances.

Of the family *Coccinellidæ* we have upwards of forty species, represented by the common ladybirds, of which the "two-spot"[1] and the "seven-spot"[2] are most frequently seen. The active larvæ are often called "niggers." They abound upon plants during the summer months, usually cast their skins three times, and eventually change to pupæ, which are fixed by the tail to a leaf or stem. Most members of this family feed on aphides and other small, soft-bodied insects, and thus render important service to mankind; but a few feed on plants.

The well-known bacon-beetle[3] is one of the family *Dermestidæ*, in which the larvæ are usually clothed with long hairs. Almost all the species feed on dried animal matter, such as bacon, leather, and skins. Some, such as the museum-beetle,[4] are very destructive to zoological collections. The raspberry-beetle,[5] however, is exceptional. The adults eat the essential parts of raspberry and bramble blooms, and the larvæ feed on the "receptacles" of the fruit.

The family *Ptinidæ* also comprises a number of destructive species, among which the "bread" or "paste" beetle[6] stands conspicuous, since it feeds on almost all kinds of dried animal or vegetable substances. It has even been known to subsist for several consecutive generations on a diet of opium! Most members of the family, however, eat wood, *Anobium domesticum* being the culprit usually re-

[1] *Coccinella bipunctata.* [2] *C. septempunctata.*
[3] *Dermestes lardarius.* [4] *Anthrenus museorum.*
[5] *Byturus tomentosus.*
[6] *Anobium paniceum*; also called *Sitodrepa paniceum.*

sponsible for the "worm-eaten" condition of our furniture. This insect and its allies are the common "death-watches," to which reference has already been made (p. 33). They have the habit of striking their head or jaws against the wood beneath them, thus producing a regular ticking sound, which is very mysterious to those who are unacquainted with its true cause. In this family the larvæ are soft, curved grubs, like those of the series Lamellicornia in miniature.

The well-known "soldier" and "sailor" beetles,[1] that abound on plants during the summer, are probably the most familiar examples of the family *Lampyridæ*, or *Malacodermidæ*, as it is called by many authors. Among their allies is the glow-worm,[2] remarkable for its light-giving powers. The male glow-worm has wings and elytra, and flies well; but the female scarcely differs in appearance from the full-grown larva, save that her legs and antennæ are more perfectly developed. The bright spots of light that we see among herbage on warm evenings are due chiefly to the presence of female glow-worms, and proceed from the underside of the abdomen, near its tip, where certain of the segments are lighter in colour than the rest; but all stages of the insect, even the eggs, are luminous in a less degree. Members of this family are especially characterized by the softness of their integument. The active larvæ feed, according to their kind, on small molluscs, worms, and a variety of decaying substances.

The "skipjacks" or "click-beetles," of the family *Elateridæ*, get their popular names from their remarkable power of jumping when placed on their backs.

[1] *Telephorus.* [2] *Lampyris noctiluca.*

The prothorax is loosely jointed to the mesothorax, and there is a dagger-like projection, or "prosternal process," on the underside of the former. By suddenly forcing this process into a groove or cavity of the mesothorax, the beetle is able to hurl itself high into the air. The larvæ of the common click-beetles are the "wireworms," which are so injurious to cultivated crops.

Before concluding this chapter, mention must be made of the little family *Stylopidæ*. It comprises certain very small insects whose structure is so remarkable that some entomologists treat them as a separate order; the majority, however, regard them as aberrant beetles. The males have the fore-wings greatly reduced and curiously twisted; but their hind-wings are broad, and are folded lengthwise when not in use. The antennæ are branched and the mouth-parts feeble. The females are blind and worm-like, and spend their lives within the bodies of bees and other insects, where they are visited by the free-flying males. The minute, active larvæ are hatched within the mother's body, and swarm upon the host insect. If the latter should be a bee, the larvæ are conveyed to its nest, and some of them bore into bee-grubs, and change to legless maggots. The bee and its parasite develop simultaneously; but whereas the female Stylopid remains a parasite throughout its life, the male escapes soon after its host becomes a winged insect.

CHAPTER VII

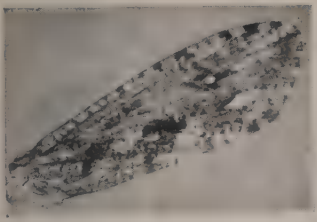
CADDIS-FLIES, MOTHS, AND BUTTERFLIES

THE caddis-flies were formerly included with the Neuroptera, but they are now treated as a distinct order (the fourteenth on our list—viz., Trichoptera). They are not only moth-like in appearance, but many details of their structure indicate actual relationship with the less specialized Lepidoptera, or "scale-winged" insects. For example, they agree with the members of the two lowest families of moths in having on the hind margin of the fore-wings, near its base, a little process (called the *jugum*) which apparently serves during flight to co-ordinate the action of the two wings of the same side.

Caddis-flies have long, slender antennæ, with many joints. When at rest, the fore-wings are brought together like a roof above the hind-wings, which fold up fan-wise. The mandibles of the adults are either absent or very rudimentary, while the two pairs of maxillæ unite with the labrum to form an imperfect sucking apparatus. The larvæ, however, have biting mouth-parts, and feed on vegetable matter. They live in ponds and streams, and are the well-known "caddis-worms," which build protective cases of small stones, shells, pieces of stick, etc., fixed together with silk spun from the mouth. Their thoracic legs are well developed, while there are two strong hooks

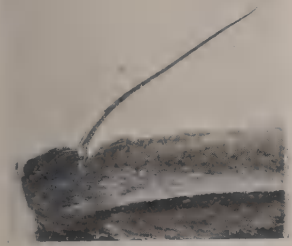
at the extremity of the abdomen, which serve to anchor the creature to its case. Breathing is effected b thread-like gills that trail from certain of the abdominal segments, and are constantly bathed with water, which circulates freely in the space betweer the larva's body and the inner wall of its abode. After feeding for several months, the larva closes both ends of its case with a webbing of silk, and change to a free pupa (p. 62), which closely resembles the mago, save that it is equipped with powerful mandibles. The latter serve to bite a way out of the case and are discarded with the pupal skin at the fina moult. After effecting its escape, the pupa swims to the surface of the water, using its middle legs, which are developed like oars for the purpose. It the climbs up some convenient stem or post; its skin splits down the back, and the perfect insect emerges. There are about 150 British caddis-flies, the larg species of the genus *Phryganea* (whose larvæ inhabit still waters) being most likely to attract attention.

Moths and butterflies make up the fifteenth order or Lepidoptera, which gets its name from the minute overlapping scales which clothe the bodies and wings of the insects concerned. In the adults of certain families all the mouth-parts are rudimentary and no food is taken; but usually the first maxillæ are elongated and grooved on their inner surfaces, so that when in apposition they form a tube, or proboscis through which liquids can be sucked into the mouth. The other mouth-parts are generally very small or absent, except the palpi of the second maxillæ, which are well developed. We have already seen that in the lowest families of moths a jugum is present at the base of each fore-wing. Most other moths have

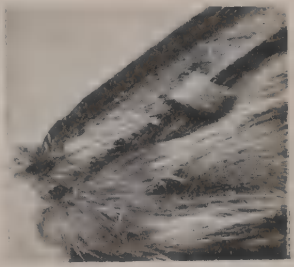


WING OF CADDIS-FLY
Note jugum at base

MOUTH-PARTS OF HAWK-MOTH,
FROM BENEATH



FRENULUM OF HAWK-MOTH



RETINACULUM OF HAWK-MOTH

POPLAR HAWK-MOTH
(Smerinthus)

EMPEROR MOTH
(Saturnia)

frenulum at the base of each hind-wing, which hooks under a kind of strap (the *retinaculum*) on the underside of the fore-wing. In the male the frenulum is usually a single curved bristle, but in the female it commonly consists of three stiff hairs. This interlocking arrangement is not universal, however, for in some moths, and in all butterflies, the co-ordination of the two wings of the same side depends solely upon the underlapping of the fore-wing by the anterior part of the hind-wing.

The larvæ of Lepidopterous insects are always caterpillars, usually with five pairs of prolegs, though there are many remarkable exceptions to this rule. They generally feed on vegetable matter, but a few kinds (*e.g.*, those of the "clothes-moths") eat substances of animal origin, such as wool or feathers. Among the lowliest of all moths the pupa is free, and, like that of the caddis-fly, equipped with functional mandibles; but as we pass from the lower to the higher families, we find that the pupa becomes more and more obtected—*i.e.*, covered by a general hardening and thickening of the outer skin, and consequently less and less capable of movement. The pupal stage is usually passed in concealment, either in a subterranean cell, or in a cocoon; but, with the exception of some "skippers," butterflies do not spin cocoons.

What is the difference between a moth and a butterfly? From the scientific standpoint no satisfactory distinction can be made. It has already been said that butterflies have no frenulum, but the same is true of certain moths; while most of the other tests that have been suggested—such as the manner of holding the wings in repose, or whether the insect flies at night or by day—are by no means infallible.

So far as British species are concerned, it will be found that the antennæ of butterflies are clubbed at the tip, whereas those of moths, notwithstanding their great diversity of form, usually terminate in a point. Nevertheless, we shall do well to admit frankly that no sharp line separating moths from butterflies can be drawn.

The order Lepidoptera is represented in the British Islands by considerably more than 2,000 species. These fall into numerous families, of which only the more important can be mentioned here.

The family *Micropterygidæ* includes the least specialized moths, which are evidently related to the caddis-flies. The species are all small, and unlikely to attract the notice of the casual student. It is worthy of note, however, that in one genus the mandibles of the adults are developed, and that throughout the family the pupa is free, with functional jaws, which it uses to extricate itself from the cocoon. The perfect moths fly in springtime round the branches of trees, while the larvæ feed (according to their genus) either in wet moss or in the soft tissues of leaves.

The well-known swift-moths[1] are also of lowly origin, and agree with the members of the preceding family in certain details of structure, notably in possessing a jugum at the base of the fore-wing. The pupa, however, has no mandibles. The larvæ feed on roots, and often take two years to attain their full growth; but the adults have rudimentary mouth-parts, take no food, and hence are short-lived. The family includes five British species, the most interesting being the ghost-swift.[2] The male, which has shining white wings, hovers in the evening above

[1] *Hepialidæ*. [2] *Hepialus humuli*.

herbage, and attracts the female by an odour given off by dense tufts of long hairs on the tibiæ of the hind-legs. The wing-colour of the female is ochreous yellow, and there can be little doubt that this dissimilarity of the sexes is due to natural selection—the whitest males in each generation being most likely to mate, since they are most readily seen by the females. This view is supported by the fact that in Shetland, where the summer nights are very light, the male is often yellow like the female.

In members of the family *Zygænidæ* we find, for the first time, a frenulum at the base of the hind-wing, and the proboscis is well developed. There are two genera—viz., the burnets,[1] and the foresters,[2] all the species flying by day, preferably in sunshine. The typical larva of the family is short and stout. Before changing to the pupa, it spins a strong, elongate cocoon on a stem of grass or some other plant.

In the family *Psychidæ* the caterpillar constructs a silken case covered with fragments of stick or refuse. The adult female is grub-like in form, and wholly helpless. She never leaves her case, but is visited therein by the male, which has well-developed wings, and flies with considerable strength and swiftness, usually by day. We have only three British species.

The clearwings[3] make up another family of day-flying moths, whose larvæ feed in wood, or in the rootstocks or stems of plants, the commonest being that of the currant-clearwing, which burrows in the twigs of currant bushes and destroys the pith. The adult moth[4] appears in June, and is common in most gardens, where it frequents flowers of various kinds.

[1] *Zygæna.*
[2] *Procris*; *Ino* of some authors.
[3] *Sesiidæ.*
[4] *Sesia tipuliformis.*

Members of this family get their popular name from the fact that the wings are in great measure free from scales, and hence transparent. Owing to this peculiarity, and to their coloration, several of the species resemble stinging insects of the order Hymenoptera. For example, *Trochilium apiforme*, whose larvæ feed in the trunk and roots of the poplar, might pardonably be mistaken at first sight for a large wasp, or a hornet; and this "mimetic" likeness probably stands the moth in good stead by warding off the attacks of birds and other insectivorous creatures.

The family *Cossidæ* is represented by the big goat-moth.[1] Its red-brown larvæ feed in the solid wood of living trees, and take several years to reach maturity. The full-grown caterpillar, which may be three inches or more in length, pupates just inside the entrance to its burrow, first forming a cocoon of chips. The pupa works its way out of the cocoon, and partly out of the tree, prior to the emergence of the moth. Some authorities regard the wood-leopard-moth[2] and the reed-moth[3] as *Cossidæ*, but others prefer to treat them as a distinct, but closely-allied, family—viz., *Zeuzeridæ*.

The family *Tortricidæ* comprises considerably more than 300 British members. Although they are all small moths, their structure indicates affinity with the goat-moth and clearwings. Most of the species may be recognized by the "squared" outline of the fore-wing at the tip. The caterpillars of many species—*e.g.*, the beautiful green oak-moth[4]—feed in rolled-up leaves, while others bore into the tissues of plants. Those of the notorious codlin-moth[5] burrow in apples, where they feed chiefly on the core and pips.

[1] *Cossus ligniperda.* [2] *Zeuzera æsculi.* [3] *Phragmatœcia castaneæ.*
[4] *Tortrix viridana.* [5] *Carpocapsa pomonella.*

The allied family of small, often minute, moths, known as *Tineidæ*, includes many hundreds of indigenous species, whose wings are usually narrow and pointed, fringed with long hairs. The larvæ generally live in concealment, but they have very various habits. Many, such as the bramble-leaf miner,[1] make tortuous tunnels between the upper and lower epidermis of leaves. Some spin leaves together. Not a few feed on stored goods of various kinds, and are very destructive, among these being the clothes-moths of our boxes and wardrobes. Indeed, the common yellow clothes-moth, known as *Tineola biselliella*, is a very good type of the family as a whole.

We now come to the two families of "plume-moths." The first, or *Pterophoridæ*, may be represented by the white plume,[2] whose wings are divided by deep clefts between the chief nervures—two clefts in each fore-wing, three in each hind-wing. The larva is hairy, and feeds on convolvulus leaves. The pupa is suspended from a leaf by its tail, like the chrysalides of some butterflies; but it is incompletely obtected, and certain of its abdominal segments are freely movable. The twenty-four plume[3] is the sole British member of the second family—the *Orneodidæ*—and has each wing six-cleft almost to the base. This little moth stands apart from, and at a higher level than, the preceding families, but agrees with those that follow in the fact that its pupa is completely obtected, with little power of movement. Its larvæ feed among the flower-buds of honeysuckle.

The family *Pyralidæ* includes about 150 British species, which are arranged in several sub-families.

[1] *Nepticula aurella.* [2] *Pterophorus pentadactylus.*
[3] *Orneodes hexadactyla.*

A fairly good type is the familiar small magpie-moth,[1] whose larvæ feed on the stinging-nettle. The grass-moths[2] that abound in meadows in summer, the wax-moths[3] that infest the combs of bees, and the flour-moth,[4] that is such a nuisance in corn-mills and bakeries, are other well-known examples; but the so-called china-marks[5] are perhaps the most remarkable group, for their larvæ feed on submerged water-plants, and in some instances are furnished with gills.

The hook-tips, with six indigenous species, make up the family *Drepanulidæ*. The characteristic hooked shape of the fore-wing is an obvious distinction, while the larvæ have no prolegs on the hindmost segment, which is prolonged into a pointed process, raised up when the creature is at rest.

The family *Lasiocampidæ* is represented in Britain by eleven species, including the eggar- and lackey-moths, as well as the drinker,[6] and the lappet.[7] These have no frenulum, and the proboscis is obsolete, no food being taken in the adult stage. The antennæ are doubly pectinated, or "feathered," in both sexes. The caterpillars are stout, hairy, and have the usual number of prolegs. When full fed they spin dense cocoons above ground.

The family *Lymantridæ*[8] likewise includes eleven British species, which resemble the foregoing in the absence of a proboscis; but a frenulum is present, and the antennæ are bipectinate only in the males. These are the so-called tussock-moths, whose larvæ have

[1] *Botys urticata.* [2] *Crambinæ.* [3] *Galleriancæ.*
[4] *Ephestia kühniella.* [5] *Hydrocampinæ.*
[6] *Odonestis potatoria.* [7] *Gastropacha quercifolia.*
Or *Liparidæ.*

dense tufts (or "tussocks") of stiff, sometimes poisonous, hairs on their backs. A well-known example is the "hop-dog," which is the caterpillar of the pale tussock.[1] The common vapourer[2] also belongs to this family. Its large-bodied female, with mere vestiges of wings, lays her eggs all over the surface of the cocoon from which she creeps, and then dies.

Everyone knows the showy tiger-moth,[3] and its caterpillar the "woolly bear." This insect is one of the family *Arctiidæ*, which comprises some forty British species, including the "footmen" and "ermines," as well as some less familiar forms. In all these moths a frenulum is present, and there is a well-developed proboscis. With few exceptions the larvæ are hairy, and pupate above ground in a rather frail cocoon. In this family many of the moths and their larvæ are very brightly coloured. Some, at least, have been shown experimentally to be examples of what is called "warning coloration," the insect's conspicuousness being associated with some character, such as a nauseous flavour, which renders it distasteful to its would-be destroyers.

The great family of the owl-moths[4] includes considerably more than 300 British members. The majority of the species are dull-coloured, and fly at night, resting by day upon tree-trunks or fences, where they are often very difficult to discover—the tints of the fore-wings (which fold over and conceal the hind-wings) harmonizing perfectly with the background against which they are seen. This "protective resemblance," as it is called, is especially remarkable when, as in the case of the common red-underwing,[5]

[1] *Dasychira pudibunda.* [2] *Orgyia antiqua.* [3] *Arctia caja.*
[4] *Noctuidæ.* [5] *Catocala nupta.*

the hind-wings are showily coloured. A fairly good type of the *Noctuidæ* is the well-known cabbage-moth,[1] whose smooth-skinned larva, which has ten prolegs, burrows into the soil before changing to the pupa. But the form of the larva and its habits varies a good deal in the different sub-families. For instance, the caterpillar of the beautiful burnished-brass-moth[2] has a "semi-looping" gait, its prolegs being reduced to three pairs; while when full grown it spins a cocoon of white silk among the leaves of its food-plant—the stinging-nettle.

The family *Notodontidæ*, of which we have twenty-five species, is made up of the puss- and kitten-moths, the prominents, and their allies. The caterpillars are often curiously shaped, without anal prolegs—as in the case of the puss-moth,[3] whose life-history is portrayed on Plate II.; but some of the species—*e.g.*, the buff-tip[4]—have larvæ of ordinary form, with the usual ten prolegs. Moreover, whereas the buff-tip caterpillar merely buries itself in the soil before changing to the pupa, some kinds spin elaborate cocoons. The cocoons of the puss-moth and its nearest relatives are hard, wood-like structures attached to the bark of trees.

We have already observed in certain of the Noctuid larvæ a tendency to dispense with some of the normal prolegs. In the family *Geometridæ* (the carpets, pugs, and their kindred) almost all the larvæ, of which we have about 270 species, have got rid of all but two pairs of prolegs—these being at the hinder end of the body. Consequently, the creature moves by first grasping a twig or leaf with its six thoracic legs, and then bringing its prolegs forward until they nearly

[1] *Mamestra brassicæ.*
[2] *Plusia chrysitis.*
[3] *Cerura vinula.*
[4] *Phalera bucephala.*

touch the thorax, the middle part of the body being thrown into a strong curve or loop as each "step" is taken. Hence, these larvæ are known popularly as "loopers." Many of them are also called "stick-caterpillars," because, when at rest, they have the habit of holding on to the food-plant by their prolegs, and stretching themselves out stiff and straight, so that they resemble a shoot or twig. But this means of protection, though very general in the family, is not universal, a well-known exception being the conspicuous caterpillar of the magpie-moth,[1] which is known to be distasteful to most insectivorous creatures, and may thus be regarded as an instance of "warning coloration." In general terms, the Geometers may be described as slender-bodied moths, having the same pattern on the fore- and hind-wings—the wings being commonly spread out when the insect is at rest. The method of pupation varies greatly in different species, but usually the full-fed caterpillar either spins a cocoon among the leaves of the food-plant, or else buries in the soil.

The hawk-moth family[2] is represented in Britain by seventeen species, several of which can only be regarded as chance migrants from the Continent. Probably the commonest is the privet-hawk.[3] It is a fairly good type, although some of the species—*e.g.*, the poplar-hawk[4]—have broader wings, and are less rapid in flight. The build of the humming-bird hawk[5] is also different, while its two clear-winged relatives, the "bee-hawks," have a mimetic likeness to humble-bees that is apt to confuse the tyro. The hairless cater-

[1] *Abraxas grossulariata.*
[2] *Sphingidæ.*
[3] *Sphinx ligustri.*
[4] *Smerinthus populi.*
[5] *Macroglossa stellatarum.*

pillars of hawk-moths have ten prolegs, and (in all the British species) a spine, or "tail," on the last segment. The full-fed caterpillar burrows into the soil, and by working itself round and round, forms a cell, wherein it changes to the pupa.

Two other British moths call for notice: First, the emperor,[1] which is the sole British representative of its family, the *Saturniidæ;* second, the Kentish glory,[2] which constitutes a family in itself, since it stands remote from all other known Lepidoptera. Superficially, these two species do not seem very dissimilar. In both the proboscis is rudimentary, and the frenulum absent; but the number and arrangement of the nervures in the wings—characters upon which systematic entomologists rightly lay great stress—differ greatly, and indicate two perfectly distinct lines of descent. The handsome caterpillar of the emperor-moth is not uncommon during July and August upon heath, birch, and other plants. When full grown, it spins a dense, pear-shaped cocoon, from which the imago emerges in May of the following year. The Kentish glory, though widely distributed in Britain as far north as the Caledonian Canal, occurs only in certain favoured localities. Its caterpillars, which feed on birch, resemble those of the hawk-moth family; while the pupa has the habit (very unusual among highly-specialized moths) of working its way completely out of its cocoon some days prior to the emergence of the moth. Both the emperor and the Kentish glory are examples of the phenomenon known as "sex-dimorphism"—*i.e.*, the coloration of the male is very different from that of the female.

The remaining families of Lepidoptera comprise the "butterflies." In all the species the proboscis is de-

[1] *Saturnia pavonia.* [2] *Endromis versicolora.*

veloped, the antennæ are dilated towards the tip to form a gradual or abrupt club, while the hind-wing is without a frenulum. With the exception of the "skippers," which stand somewhat apart from the other families, butterflies form a compact and isolated group. We must not infer, however, that this group is equal in systematic importance to the whole of the moths. On the contrary, we should regard it as an offshoot from one of the main branches of the genealogical tree of Lepidoptera. Butterflies are more nearly related to the higher moths than these are to the lower.

So many books about British butterflies are available, that our present purpose will be amply served by a brief outline of the peculiarities which characterize the several families.

The skippers [1] are thick-set insects that fly rapidly, and rest with their wings spread out. In both sexes all the six legs are fully developed, and serviceable for walking. The larvæ are somewhat spindle-shaped, with few hairs. When full grown, they spin slight cocoons among leaves, except in the case of the chequered skipper,[2] whose pupa is attached by the tail, and supported by a belt of silk.

The males of all blues, hairstreaks, and coppers,[3] have the tarsi of the fore-legs more or less shortened, or with one or both the claws absent; while in both sexes the neuration of the wings differs—in the direction of greater specialization—from that of the skippers. The larvæ are very characteristic in form, being somewhat like wood-lice in appearance. The pupa is clothed with short hairs or bristles, and is generally fixed by the tail and belted, but may be unattached, or even buried in the ground.

[1] *Hesperidæ.* [2] *Cyclopædes palæmon.* [3] *Lycænidæ.*

The little Duke of Burgundy fritillary [1] is the only British representative of a family [2] whose headquarters are in tropical America. The fore-legs of the male are so much reduced that they are useless for walking. The larva resembles those of the last family, but has tufts of short, stiff hairs on its back.

The swallow-tail butterfly [3] stands apart from the other species, being one of the great family *Papilionidæ*, whose members abound in the tropics. The six legs are fully developed in both sexes, and the neuration of the wings differs conspicuously from that of all other butterflies. The larva is cylindrical, devoid of hairs, and has behind the head a curious two-pronged process. This is usually retracted and invisible; but it can be shot out and made to emit a strong odour that is believed to protect the caterpillar from ichneumons and other enemies. The pupa, which has two projecting frontal tubercles ("nose-horns"), is fixed by the tail to a pad of silk, and kept upright by a silken girdle. This fixing of the pupa's tail, by the way, is effected by a projection (the *cremaster*) which is beset with microscopic hooks that become entangled with the silk fibres.

The "white butterflies," including the orange-tip, brimstone, and clouded-yellows, make up the family *Pieridæ*. They agree with the swallow-tail in having all six legs fully developed in both sexes; but the wing-neuration is different. Moreover, the larva is clothed with close, short hairs, while the pupa has only one "nose-horn."

Members of the family *Nymphalidæ*, which comprises our fritillaries, tortoiseshells, meadow-browns, etc., differ from all other butterflies in the fact that the fore-legs are much reduced, and useless for walking,

[1] *Nemeobius lucina.* [2] *Lemoniidæ.* [3] *Papilio machaon.*

n both sexes. The caterpillars in some genera are armed with formidable spines, in others they are smooth-skinned; but the pupa has always two "nose-horns," and usually hangs head downwards by its cremaster from a silk pad, without any girdling thread. The following sub-families should be noted: The *Nymphalinæ*, including the fritillaries, tortoiseshells, admirals, etc., have spiny caterpillars, and the pupa is often resplendent with metal-like patches, thus meriting the name chrysalis. The famous purple-emperor[1] is the only British representative of the sub-family *Apaturinæ*, in which the larva is smooth and slug-like, with two long tentacles on the head. In the case of the meadow-browns and their allies,[2] the larvæ are clothed with short hairs, and taper somewhat towards the extremities. The pupa is usually suspended by the tail; but in one or two instances—*e.g.*, the marbled-white[3]—it is hidden in moss, among roots, or just below the soil.

The number of British butterflies is usually given as sixty-eight; but this includes one extinct species—the famous large-copper,[4] and four that are merely occasional immigrants—viz., the Bath-white,[5] the Queen-of-Spain fritillary,[6] the long-tailed blue,[7] and an insect that is known in its American home as the "monarch," or "milkweed butterfly."[8] The last named is a great traveller, and since 1870 or thereabouts has extended its range from the new to the old world by way of the Pacific Islands, and bids fair to become wellnigh cosmopolitan. It is a member of a distinct Nymphaline sub-family—viz., *Danainæ*.

[1] *Apatura iris.*
[2] Sub-family *Satyrinæ.*
[3] *Melanargia galathea.*
[4] *Chrysophanus dispar.*
[5] *Pieris daplidice.*
[6] *Argynnis lathonia.*
[7] *Polyommatus* (*Lycæna*) *bætica.*
[8] *Anosia erippus*; also called *Anosia plexippus.*

CHAPTER VIII

TWO-WINGED FLIES AND FLEAS

NEARLY all winged insects are known popularly as "flies," but the name is most fittingly applied to members of the sixteenth order, or Diptera. These are the "true flies," or "two-winged flies," which differ from all other insects in having the hind-wings reduced to tiny stalked knobs, or halteres (p. 7), the fore-wings alone being used for flight. These functional wings are usually transparent, with not more than seven longitudinal nervures. The compound eyes are generally large and conspicuous. When present, the mouth-parts are greatly modified so as to serve for piercing and sucking, or for sucking only. The common grey gnat, or mosquito, for example, has no less than six needle-like stabbing instruments, that are believed, with good reason, to represent the mandibles, first maxillæ, labrum, and "tongue" of a typical mandibulate insect, such as the cockroach. All the six needles lie normally within a grooved sheath (the modified second maxillæ, or labium); but when a gnat "bites," the needles are driven through the skin of the victim, while the sheath loops back under the insect's head. The extreme tip of the sheath, however, remains closely pressed to the skin, and surrounds the needles. The actual sucking-tube, through which blood is drawn

LARVA AND PUPA-SKIN OF CRANE-FLY
(Tipula)

LARVA AND PUPARIUM OF BLOW-FLY
(Calliphora)

CRANE-FLY, OR "DADDY-LONGLEGS"
(Tipula)

DRONE-FLY
(Eristalis)

KED, OR "SHEEP-TICK"
(Melophagus)

into the mouth, probably consists of the labrum and tongue in conjunction, the needles which represent the mandibles and maxillæ being chiefly used to enlarge the wound. In the Central Hall of the British Museum (Natural History) some enlarged models of a gnat's head and mouth-parts are exhibited. These show clearly the positions of the several organs, and the manner in which they work. Students who are able to visit the Museum should not fail to examine these models carefully.

Among those Diptera that are able only to suck, all the mouth-parts except the labium have become obsolete; but the labium is a very wonderful organ, which ends in a bilobed, fleshy pad. When not in use it lies in a cavity beneath the head; but, being jointed, it can be extended when the insect is feeding. The pad is traversed by numerous ducts, that act as tributaries to two main tubes which communicate with the mouth. It acts like a kind of sponge, readily absorbing liquids, or even small solid bodies, such as pollen grains. Moreover, the fly is able to flood the ducts of the pad with saliva in order to soften or dissolve hard substances that would otherwise be unsuitable for food. It is in this way that the house-fly is able to eat lump sugar.

Diptera may be divided into two sub-orders in accordance with the character of the larva, and the manner in which the pupal skin splits to allow for the escape of the imago. All Dipterous larvæ are destitute of thoracic legs; but in the first sub-order[1] there is a small but distinct head, while the pupal skin splits longitudinally down the back. The flies of this sub-order are arranged in numerous

[1] *Orthorrapha.*

families, which fall naturally into two groups. In the first group[1] the antennæ are slender and thread-like, composed of at least seven joints, usually of many more. This group comprises the midges, gnats, crane flies, and their allies. The most interesting families are the following:

The gall-midges[2] are tiny, gnat-like flies, whose family name has reference to the fact that many of the species, as larvæ, affect the tissues of plants in such a way that abnormal growths or galls are produced. For instance, the midge called *Cecidomyia saliciperda* lays her eggs in rows on the bark of willow stems, and the minute grubs, on hatching, burrow inwards. They so irritate the cambium—*i.e.*, the actively growing tissues of the stem—that eventually a spindle-shaped swelling is produced; and in the end the bark ruptures and hangs down in shreds. When a stem several inches in circumference is attacked by numerous midges, a very large gall-structure may result, such as the specimen shown in the photograph reproduced on Plate XI., which measures nearly a foot in length. The tiny punctures scattered over the surface bear testimony to the vast swarms of midges that must have issued from this great gall. Many other midge-caused galls, some of them curiously shaped and prettily coloured, may be found on different kinds of plants; but membership of this family by no means necessarily implies the gall-making habit. The larvæ of many Cecidomyids—*e.g.*, the notorious Hessian-fly[3]—do great harm to plants by secreting themselves in the tissues and sucking the sap, the process being unaccompanied by any abnormal growth on the part of the vegetable cells. The larvæ of other species

[1] *Nematocera.* [2] *Cecidomyidæ.* [3] *Cecidomyia destructor.*

feed on dead animal matter, and a few prey on aphides and mites.

The family *Bibionidæ* includes stoutly-built flies, with relatively short antennæ. The eyes are exceptionally large, especially in the males. The sexes differ remarkably in colour, the females being usually red or yellow, the males deep black. The larvæ feed on the roots of grass and other plants, or in decaying vegetable matter. In spring or early summer the perfect flies may often be seen in enormous numbers among the herbage in meadows and open places.

The so-called sand-midges[1] are small black or greyish flies, of which there are about a dozen British species. They are chiefly remarkable for their blood-sucking habits, and the annoyance which they cause to man and beast. The early stages of the life-history are passed in running water, where the larvæ feed on minute vegetable organisms, such as algæ or diatoms.

The true midges[2] are for the most part harmless, but certain species of the genus *Ceratopogon* are inveterate blood-suckers, and are chief among the pests that haunt our gardens in the summer twilight. In this family, also, metamorphosis is usually accomplished in the water, or in damp situations. The form of the larvæ and their habits are very varied. Some species, known as "blood-worms," live in mud at the bottom of stagnant or dirty water. They are especially interesting because their red colour is due to the presence in their bodies of hæmoglobin—the same oxygen-attracting substance that gives colour to our own blood.

The family *Culicidæ* comprises the gnats or mos-

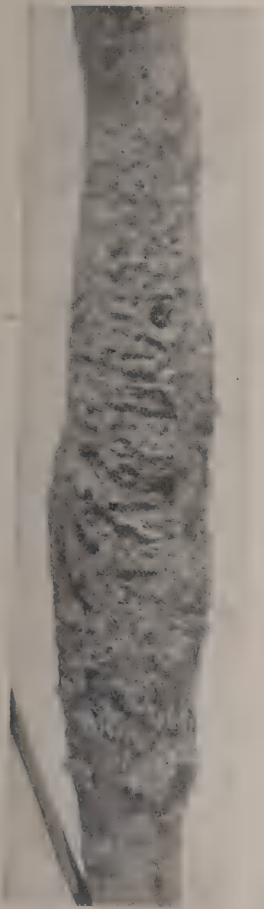
[1] *Simulid* .

[2] *Chironomidæ*.

quitoes, the two popular names being synonymous, notwithstanding the current belief that a "mosquito" is a much more formidable insect than a "gnat." Some of the spotted-winged gnats (or mosquitoes) of the genus *Anopheles* which are found in Britain are, in other countries, responsible for the spread of the parasite that causes malarial fever; but since this disease has disappeared from our islands, the "bite" of these insects is attended by no more serious consequences than temporary local inflammation. The common grey gnat[1] is another troublesome blood-sucker, but is not, so far as is known, concerned in the spread of disease in any part of the world where it occurs. All told, there are about twenty-two species of British gnats, including some that have not been observed to "bite." The larvæ are all aquatic, and feed on minute organisms, both animal and vegetable. Those of the genus *Culex* are the familiar "wrigglers" that are so common in water-butts and cisterns in the summer. Each is furnished with a respiratory tube near the tail-end, and this communicates with the tracheal system. When taking in air the *Culex* larva suspends itself at an angle from the surface-film, whereas the differently shaped larva of *Anopheles* lies perfectly horizontal. The pupæ float at the surface, and breathe through a pair of trumpet-like tubes on the thorax.

It should be noted that (with one or two possible exceptions) the blood-sucking habit among flies of the sub-order Orthorrapha is confined to the female sex. The males, if they feed at all, subsist on vegetable juices—as, indeed, the females are well able to do if their favourite food is not obtainable.

Culex pipiens.



WILLOW STEM GALLED BY MIDGE
(Cecidomyia)

MARBLE GALL-WASP
(Cynips kollari)

NEST OF SOLITARY WASP
(Eumenes)

The familiar "daddy-longlegs"[1] represents the family of crane-flies.[2] The larvæ of this insect and certain of its relatives are the "leather-jackets" that do so much mischief by feeding on the roots of plants. The family is a large one, however, and the details of the life histories vary considerably. Some of the larvæ feed in the moist mould that accumulates in decaying tree-stumps; others are aquatic. The perfect insects may be recognized by their immensely long legs, which (as Dr. Sharp remarks) "break off with great ease, and the insect appears to get on perfectly well without them."

In the second group[3] of the sub-order Orthorrapha the species have never more than five joints in the antenna, usually only three. The larvæ have small, retractile heads, and are much more maggot-like than those of the preceding group. There are numerous families, among which the following are especially noteworthy:

The family *Stratiomyidæ* includes the broad-bodied "soldier" or "chameleon" flies, as well as others which are more slender in form. The species are often prettily coloured, sometimes metallic. The larvæ are chiefly aquatic, though some feed in decaying matter; but the perfect insects frequent flowers.

The robust gad-flies and their kindred make up the family *Tabanidæ*, the most familiar example being the "cleg," or rain breeze-fly[4]—a provoking blood-sucker which seems usually to pester men and horses. Throughout the family piercing mouth-parts are remarkably well developed in the females, and many of the species which attack cattle, horses, and deer, are

[1] *Tipula oleracea.*
[2] *Tipulidæ.*
[3] *Brachycera.*
[4] *Hæmatopota pluvialis.*

serious pests, on account of the annoyance caused to their victims. The males, on the contrary, are rarely seen, and are quite harmless. The great ox gad-fly[1] ranks among the largest British Diptera. The larvæ of *Tabanidæ* are found in water, earth, or decaying wood, where they feed on worms, molluscs, beetle-grubs, etc.

The alert, hairy robber-flies[2] have been termed the savages of the insect world, since they prey remorselessly upon its lesser denizens, and are extremely voracious. A single individual has been observed to kill eight moths in twenty minutes. Indeed, a member of this family is rarely seen without some other insect in its grasp. Most of our native species are unattractive; but *Asilius crabroniformis* is decidedly handsome, and has a generalized resemblance to a hornet, or a large wasp. Like other Asilids, it does not hesitate to attack stinging insects; but whether its likeness to this class of prey enables it (as has been suggested) to approach its victims without arousing their suspicion, is open to question. Probably the "mimicry" is really protective, serving to exempt the robber itself from the attacks of larger insectivorous creatures. The larvæ of robber-flies are found burrowing in damp earth. So far as is known, they feed on other insects, especially beetle-grubs.

The familiar bee-fly[3] is typical of the family *Bombyliidæ*. Being thick-set and hairy, it might easily be mistaken for a small humble-bee; but its manner of flight is very characteristic and rapid, and it rests with its wings stretched out on either side. Its mouth-parts, which form a long, stiff proboscis, are of the piercing type, but they are used only for extracting the

[1] *Tabanus bovinus.* [2] *Asilidæ.* [3] *Bombilius major.*

juices from flowers. The life-history of this insect was long unknown, and the details still call for investigation. It has been ascertained, however, that the eggs are jerked by the parent fly, when hovering, against a bank in the vicinity of a solitary bee's nest, and that the *Bombilius* larvæ feed as parasites on the bee-grubs.

The second sub-order[1] of the Diptera comprises an enormous number of highly specialized flies, whose metamorphosis is very great, the larva being usually a maggot with no definite head-capsule. In the extreme type the maggot has a broad, bluntish tail-end, and tapers almost to a point at its anterior extremity, where the mouth-orifice is situated. Here, also, we find a pair of strong hooks, moved by powerful muscles, that serve to tear up the food substance, on the juices of which the larva subsists. When one of these maggots is full-fed, its skin, instead of being cast aside, contracts and hardens to form an ovate *puparium*—a kind of protective case within which the pupa lies. Ultimately the perfect fly pushes open a circular lid at the head-end of the puparium, and creeps out. Throughout this sub-order the species have inconspicuous, three-jointed antennæ, of which the third joint is by far the largest, and bears a long, bristle-like process. In many genera there is a conspicuous lobe, called the *squama*, at the base of each wing. The most important families are the following:

The hover-flies and their allies[2] differ from all other Diptera in their wing-neuration, but in other respects the numerous species vary greatly among themselves. Some are hairy, others smooth and shining, while many are banded or spotted with yellow or orange, and are

[1] *Cyclorrhapha.* [2] *Syrphidæ.*

strikingly like wasps and bees. The chief mouth-part is the fleshy labium, but there is also a series of slender, pointed lancets. To what use, if any, the latter are put is not known, seeing that the food of these insects consists chiefly of pollen. "Honey is also doubtless taken by some species (writes Dr. Sharp), but the lancet-like organs appear equally ill-adapted for dealing with it." The form of the larva and the nature of the life-history are very diverse in this family. The hover-flies that frequent our gardens lay their eggs on plants, and their maggots do good service to mankind by preying on aphides, whose juices they suck. The common drone-fly,[1] which resembles an overgrown hive-bee in appearance, is one of a group of species whose larvæ are the "rat-tailed maggots" that feed in liquid filth or dirty puddles. The remarkable "tail" contains an extension of the tracheal system; and as it is capable of extension or withdrawal, the larva is able always to keep the tip above water, thus securing a constant supply of air. In another genus,[2] the maggots live in the nests of bees and wasps, where they were once believed to prey upon the grubs, but are now known to act as scavengers. Other Syrphid larvæ feed in fungi or decaying vegetable matter; while those of the narcissus-fly[3]—a particularly humble-bee-like species, very variable in colour—burrow into living bulbs, and cause much mischief, both in this country and in Holland.

The bot-flies,[4] in their larval state, rank among the most revolting of all parasites, feeding as they do in the nasal passages, under the skin, or in the alimentary

[1] *Eristalis tenax.*
[2] *Volucella.*
[3] *Merodon equestris.*
[4] *Œstridæ*

canal of vertebrate animals—sheep, oxen, or horses, according to the species in question. The female sheep-nostril-fly,[1] for example, drops her eggs (or perhaps newly-hatched larvæ) into the nostrils of a sheep. Growth and development take place in the cavities of the head to which the nostrils give access; and ultimately the mature "bots," as the larvæ are called, fall to the ground, where they pupate beneath stones or clods. The bots of warble-flies[2] live just under the skin of oxen, and are the cause of serious loss to stock-owners on account of the damage done to the hides. Strangely enough, the adult flies of this family are practically without mouth-parts, and take no food of any kind. They are rarely seen except when flying around the animals that they victimize.

The enormous family *Muscidæ* includes most of the species that commonly visit the habitations of mankind—the house-flies, flesh-flies, blue- and green-bottles, not to mention many less familiar kinds. All these feed, as maggots, on decaying animal and vegetable substances, each species having its own predilection and habits. One fly known as *Stomoxys calcitrans* calls for special mention, because it is nearly related to the dreaded tsetse-flies of the African continent, and, like them, has piercing mouth-parts (very exceptional endowments among the *Muscidæ*), with which it is able to suck blood. It is very much like, and is often confused with, the common house-fly;[3] and as it rarely enters houses except before rain, there is a popular belief that "flies begin to bite before rain." Of course, the real house-fly, having only a suctorial labium, never bites at all. Nevertheless, it has been convicted of contaminating our food with the

[1] *Œstrus ovis.* [2] *Hypoderma.* [3] *Musca domestica.*

germs of diseases, and every possible means for its suppression should be adopted. Both *Stomoxys* and the true house-fly breed chiefly in stable refuse. The bristly grey flesh-flies and their allies make up a distinct sub-family—viz., *Sarcophaginæ*. Most of the species are viviparous—*i.e.*, the eggs are hatched in the parent's body, and the young maggots are subsequently dropped upon suitable food. Another sub-family[1] comprises numerous flies with very bristly bodies. They lay their eggs on caterpillars, into whose tissues the maggots burrow. These parasites often cause disappointment to the collector. The afflicted caterpillars usually preserve sufficient vitality to pupate; but the pupæ eventually disclose Tachinid flies instead of the looked-for moths.

The family *Anthomyiidæ* comprises numerous small species, many of which look like tiny house-flies. In some instances the maggots feed on decaying matter of various kinds; in others they burrow into living plants, and work considerable havoc. One species called *Hylemia antiqua* is the "onion-fly," whose maggots sometimes do so much damage to onion crops.

A few highly specialized flies of strange habits make up the family *Hippoboscidæ*. They are all blood-sucking parasites, and live upon the bodies of mammals, or, more rarely, birds. The maggots are produced viviparously, and fully developed, so that they pupate shortly after leaving the parent's body. The best known example of this family is the wingless "ked,"[2] often erroneously called the "sheep-tick." Other species are winged, and one of these, the New Forest-fly,[3] has on more than one occasion attracted

[1] *Tachininæ*. [2] *Melophagus ovinus*. [3] *Hippobosca equina*.

popular notice by causing horses to stampede during army manœuvres.

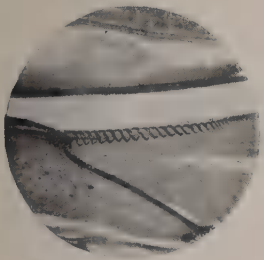
The seventeenth order, or Siphonaptera, comprises the fleas, of which upwards of forty British species are known, the largest being *Hystrichopsylla talpæ*, which infests moles. These insects are probably allied to the Diptera, but they differ from them in many important respects. The piercing mouth-parts are the lancet-like mandibles, with serrated edges, and an unpaired organ which some authorities regard as a prolongation of the labrum or upper lip, others as the modified "tongue" (hypopharynx). These three mouth-parts interlock, so as to form a sucking-tube. When not in use, they are encased in a tubular rostrum, formed by the two labial palpi. Fleas are further characterized by the entire absence of wings, and by the lateral flattening of their bodies. They may be described as "intermittent parasites," since they are not permanently attached to their victims. Moreover, only adult fleas suck blood. The white, worm-like larvæ have biting mouth-parts. They live among dust and refuse, and feed on the organic matter which it contains. When full-grown, each larva spins a small silken cocoon, wherein the pupal stage is passed.

CHAPTER IX

ANTS, BEES, WASPS, AND THEIR KINDRED

WHICH order of insects is the "highest"—*i.e.*, the most advanced in point of evolutionary progress? The question may seem superfluous, in view of the facts that many different lines of development are apparent, and that each type of insect is well fitted for the life which it leads. Yet some insects are manifestly more specialized than others. The details of their structure and metamorphosis evince such profound modification, such delicate adjustment to external conditions, that further improvement seems hardly possible. Judged by this standard of physical perfection, the more advanced families of the Diptera stand supreme; but for the highest refinement of the mental faculties we must turn to ants, bees, and wasps. These insects are included in the order Hymenoptera, which must now engage our attention.

The majority of Hymenopterous insects have four membranous wings, which are never very large, and of which the nervures are never very numerous. Except in a few minute species, the wings of each side are united during flight by a row of hooks on the front margin of the hind-wing, which engage with a fold on the hind margin of the fore-wing. These hooks cannot be seen without the aid of a fairly powerful lens, but their presence may be demonstrated by



HOOKS ON BEE'S WING

"WORKER" ANT
(Formica)

DIGGER-WASP
(Ammophila)

ICHNEUMON
(Pimpla)

SAW-FLY AND COCOON
(Trichiosoma)

SOLITARY WASP
(Eumenes)

drawing forward the wings of a newly dead bee, when the fore- and hind-wing will be seen to move in unison. A less obvious character of the Hymenoptera is the partial or entire fusion of the first abdominal segment with the thorax—the "waist," which is so marked a feature in many families, coming not *between* the thorax and the abdomen, but *behind* the first abdominal segment. Mandibles are always present in the capacity of nipping organs; but they are generally employed as tools, and have comparatively little to do with the direct service of the mouth. The maxillæ vary greatly in the different families. Among the saw-flies they are not very unlike those of beetles and cockroaches; but in the higher families they are adapted for licking or sucking. In the case of a hive-bee or a humble-bee, for example, the parts are greatly modified and of considerable length. When in close contact, they act as a suctorial apparatus, or proboscis, which is often spoken of as the insect's "tongue." But the real tongue (hypopharynx) is only a part of the compound organ, in which it occupies a central position.

Hymenoptera undergo a complete metamorphosis, the pupa being of the free type. It is usually, but not always, enclosed in a silken cocoon spun by the full-grown larva. The order is divided into two well-marked sub-orders, of which the first[1] includes the saw-flies and wood-wasps, or horn-tails, as the latter are sometimes called. In all these insects the abdomen is more or less continuous with the thorax, there being no marked constriction or "waist." The ovipositor of the female is adapted for cutting or boring, but never for stinging. The larvæ are all plant-feeders. Those which live openly upon the

[1] *Symphyta.*

leaves resemble the caterpillars of moths, but have more than five pairs of prolegs—sometimes as many as eight pairs; but those which burrow in stems or wood are white, fleshy grubs, with hard heads. There are three families in the sub-order.

The stem saw-flies, so called because their larvæ feed in the stems of plants, make up the little family *Cephidæ*. They are the least specialized of all the Hymenoptera. The pronotum is elongate, and instead of being intimately connected with the mesonotum, is free and mobile—a character which is not found in any of the succeeding families. The corn saw-fly[1] is not uncommon in the South of England. The female inserts an egg a little below the first joint of a young corn-plant, and the grub eats its way upwards, often boring through all the joints. When full-fed, it retraces its course, and spins its cocoon close to the roots, first, however, felling the plant by partially cutting through the straw at the base.

The family *Siricidæ* is represented by two British species—viz., the giant wood-wasp,[2] and the steel-blue wood-wasp.[3] The former is not unlike a hornet in its coloration, but is quite harmless. The long, horn-like process at the extremity of the female's abdomen is not a sting, but an ovipositor, by means of which she bores holes in the solid wood of trees and inserts her eggs. The white grubs feed on the wood, in which they make long tunnels. It is said that they may become full-fed in seven or eight weeks; but usually the life-history appears to be much more protracted, and instances are recorded of adult wood-wasps issuing from timber long after its incorporation in a building. Coniferous trees are usually attacked,

[1] *Cephus pygmæus.* [2] *Sirex gigas.* [3] *S. juvencus.*

and in the large pine forests of Germany and Northern Europe these insects have proved serious pests.

The insects to which the name "saw-fly" is most commonly applied belong to the family *Tenthredinidæ*, of which we have numerous indigenous species. One of the largest is *Trichiosoma tibialis*, whose caterpillar feeds on hawthorn, and ultimately spins a hard, brown cocoon on a twig. The perfect insect appears in early spring, and is not unlike a large bee, but may readily be distinguished by its long, clubbed antennæ. Another member of this family is the gooseberry saw-fly,[1] which, as a larva, ravages our gooseberry bushes. In some instances the larvæ of saw-flies feed in galls. For instance, the crimson horse-bean galls that are often so numerous on the leaves of the crack willow are caused by a species known as *Nematus gallicola*.

In the second sub-order[2] of the Hymenoptera the abdomen is constricted behind the first segment to form a "waist." The ovipositor may be merely a tool for inserting the eggs, but in the higher families it is often modified to act as a sting, the eggs then passing, not through the organ itself, but through an aperture at its base. The larva is always a legless grub, whose welfare depends upon the instinctive preparations of the parent, or (where social species are concerned) upon the daily ministrations of the "workers" of the community. This sub-order comprises by far the larger number of the Hymenoptera. Many families are recognized, among them being the following:

The gall-wasps[3] are so called because many of the species are concerned in the production of galls, in which the grubs feed. These galls are found on several kinds of plants, but most commonly on the oak.

[1] *Nematus ribesii*. [2] *Apocrita*. [3] *Cynipidæ*.

Familiar examples are the "oak-apple," which originates in a bud, and the various "cherry," "spangle," and "button" galls that are attached to the leaves. In a general way it may be said that each species of gall-wasp is bred from a gall which is perfectly distinct in form and appearance from all the other kinds, but the life-cycles of certain species involve a remarkable "alternation of generation." For example, a generation of winged gall-wasps of both sexes emerges from the oak-apple in early summer. After pairing, the females penetrate the soil, and lay their eggs in the roots of the oak. This causes a crop of subterrannean galls to be produced, and the grubs that feed therein become wingless wasps, all females endowed with the faculty of parthenogenesis, or virgin reproduction. During the winter these insects creep up the oak trunks, and by laying their eggs in the buds, give rise to the oak-apples of the succeeding spring. Thus two different galls, and what at first seem to be two kinds of insects, really all belong to one and the same species. Gall-wasps are small, dark-coloured insects. Our largest,[1] which is bred from the well-known marble-gall of the oak, is slightly less than one-sixth of an inch in length. It was not observed in England until 1834, but is now very abundant. Yet, notwithstanding diligent search, no male has been discovered. Apparently the species is perpetuating itself, year after year, through successive generations of parthenogenetic females! Not all the *Cynipidæ* are gall-causers. Some are parasites, while others are inquilines—*i.e.*, they lay their eggs in galls that have been induced by other species.

Most of the ichneumons, of which we have very

[1] *Cynips kollari*

many native species, belong to the families *Ichneumonidæ* and *Braconidæ*. They are separated in accordance with the number and arrangement of the "cells" (areas enclosed by veins) in the fore-wing; but as the species are all extremely similar in their general structure and habits, we may treat the two families as one. Ichneumons are slenderly built insects, with long antennæ. They lay their eggs either in or upon the larvæ or pupæ of other insects—Lepidopterous caterpillars being most commonly chosen for the purpose. The females are provided with ovipositors, which are often conspicuous, sometimes of great length. Among the latter are species which attack wood-boring larvæ; and it is stated that some of these will drive their ovipositors through a considerable thickness of timber in order to reach their victims. As a rule, ichneumon grubs do not seriously affect the vitality of their "hosts" until their own development is almost complete. Indeed, the host often preserves sufficient strength to assume the pupal state, and occasionally completes its metamorphosis, though this is rare. Usually it perishes soon after the parasites have left it to spin their own cocoons. One of the commonest Braconid ichneumons is known as *Microgaster glomeratus*. It implants its eggs in the caterpillars of the large-white butterfly[1] in such numbers that when the victims are full-grown their skins may be literally packed with fat Microgaster grubs. The latter eventually escape, and spin their small yellow cocoons in a mass round the body of the larva that they have done to death. "Although such parasitism raises a feeling of repulsion (writes Dr. Sharp), yet there is reason for supposing that there may be little

[1] *Pieris brassicæ*.

or no cruelty or acute suffering connected with this mode of life. The victim attacked is not eaten, the parasites in the interior taking in the lymph of the caterpillar either by the mouth or by endosmosis (*i.e.*, through the skin), but not biting their host. The latter displays no sign of sickness, but eats voraciously, so that it serves merely as a sort of intermediary between the juices of the plant and the larvæ inside itself.

The families *Chalcididæ* and *Proctotrypidæ* comprise enormous numbers of tiny Hymenoptera. They are so diminutive that they are rarely noticed, save by the few entomologists who make them their special study. Nevertheless, they are of the utmost importance to agriculturists, since many of the species are very destructive to field and garden pests. On the whole, their habits resemble those of the ichneumons, but their range of attack is much wider. Some of the Chalcids, for instance, oviposit in aphides, one egg being inserted into each victim. Many of the *Proctotrypidæ* are egg-parasites. They lay their eggs in those of larger insects, and in some instances half a dozen or more parasite grubs find sufficient nutriment for their development in a single moth's egg—a fact which bears eloquent testimony to the extreme minuteness of the adult insect. Among the smallest species of all are some that enter the water in order to lay their eggs in those of dragon-flies.

The pretty ruby-wasps[1] are noted for their brilliant metallic hues—blue, green, and crimson. They lay their eggs in the nests of bees and wasps, and their grubs were formerly believed to feed as "cuckoo parasites," eating up the food stored for the benefit of the rightful occupants of the nest; but there is now

[1] *Chrysididæ*.

good reason for thinking that the grubs of at least some species are true parasites which destroy the offspring of the bee or wasp. A common and very beautiful member of this family is *Chrysis ignita*, whose females may often be observed searching the crevices of brickwork for the nests of solitary wasps.

Nearly all our British fossors, or digger-wasps, are comprised in the two families *Pompilidæ* and *Sphegidæ*. Of the former we have about thirty species, of the latter upwards of ninety. They get their popular name from the fact that many kinds excavate burrows in the soil, though not a few drive tunnels in decayed wood, or in the stems of bramble and other plants. Mr. Latter has pointed out that whereas Pompilids, when digging, use their feet and the coxal joints of the legs as tools, Sphegids employ only their powerful jaws.[1] The far end of the burrow or nest is stored with some kind of animal food, upon or near to which an egg is laid. The Pompilids generally provision their nests with spiders; but the Sphegids commonly store caterpillars, though some use beetles, two-winged flies, aphides, etc., for the purpose. Usually each species selects one particular kind of prey, which, however, it does not actually kill, but paralyzes by skilfully stinging one or more of the chief ganglia or nerve-centres. In this way two ends are served: the victim is unable to struggle while it is being conveyed to the burrow, or to escape when it has been deposited therein; yet it remains untainted until it is required as food by the wasp-grub. Our largest Sphegid wasp is *Ammophila sabulosa*, a black and red species, with a remarkably long "waist." It frequents such places as gravel-pits, or dry patches of bare soil on commons;

[1] "Bees and Wasps."

and here the females may sometimes be seen busy with their digging. When the burrow is complete, the insect has the interesting habit of closing the entrance with a small stone, or a little lump of earth, before she sets forth in search of her caterpillar prey.

Ants[1] may be distinguished from all other Hymenoptera by the fact that the one or two segments that constitute the "waist" are nodular in form. Moreover, the imperfectly developed females, or "workers," are always wingless; and these are the ants that we usually see during the course of a country ramble. All ants are social insects, living together in co-operative communities, which comprise one or more sexually perfect females, or queens, and large numbers of workers. The latter build the nests, gather food, and care for the young, while the queens are concerned only with egg-laying. The bulk of the eggs laid in any season serves to augment the worker population; but towards the end of the summer a brood of winged males and females is produced. These individuals leave the nest to pair, and although most of them are quickly destroyed by birds and other insectivorous creatures, a few of the queens succeed in founding new communities. It is a curious fact that a queen, after her nuptial flight, casts her wings, or is deprived of them by the workers. Ants' nests are formed in different situations, and in a variety of ways, according to the species concerned. Some of the large kinds, of which the wood- or horse-ant[2] is the best known, build up huge mounds of fir needles, small twigs, etc., and excavate galleries and chambers that extend far into the ground below. Others, such as the common yellow ant,[3] throw up hummocks of earth,

[1] *Formicidæ*. [2] *Formica rufa*. [3] *Lasius flavus*.

which soon become clothed with vegetation. Others, again, make their habitations in rotten wood, in bramble stems, among moss, or beneath stones. The popular belief that ants, or "emmets," can sting is only partially true. The large ants of the fir woods have no stinging apparatus, although they are able to eject an acid poison from the tip of the abdomen into a wound that they have made by biting. Some of our small ants, however, have stings. The members of an ant community do not die off at the approach of winter, but retire to subterranean chambers, where they hibernate. Ants are noted for their habit of allowing, or actually encouraging, other insects to live with them in their nests. Among these "guests" are aphides and certain kinds of beetles, whose secretions are palatable to the ants; but there are other insects which appear to give nothing in return for the hospitality that they receive, and why these should be tolerated is not known.

The true wasps,[1] as distinct from the digger-wasps, referred to above, may be easily recognized by the fact that the fore-wing is folded lengthwise when the insect is at rest, the hinder half of the wing being doubled under the front half. So far as the writer is aware, this character is not seen in any other Hymenoptera. The family is divided into two sub-families—viz., the solitary wasps[2] and the social wasps.[3] Members of the former group have one spine on the tibia of the middle leg where it joins the tarsus, and the tarsal claws of all the legs are toothed. Further, the species are solitary in habit—*i.e.*, they do not live in communities, but each female builds and provisions her own nest-cells without assistance from other members of her kind. Our sixteen British species are

[1] *Vespidæ.* [2] *Eumeninæ.* [3] *Vespinæ.*

small, black insects, striped and marked with yellow. Fifteen of them belong to the genus *Odynerus*. They make their nests in burrows, in plant stems, and in the crevices of masonry; while some of the species have been known to build in door-locks, and in the holes of cotton-reels, blind-tassels, etc. One individual actually made her nest in the barrel of an old pistol that had been left in an outhouse. It is often stated that these insects use mud when constructing their cells; but some, at least, employ particles of dry soil, which they cement together with their saliva. The sixteenth species[1] has a remarkably long "waist." It builds its globular nests on the twigs of low-growing plants, usually choosing heather (Plate XI.). All our *Eumeninæ* provision their cells with tiny caterpillars, which they paralyze by stinging, after the manner of the digger-wasps.

The social wasps of the sub-family *Vespinæ* have two tibial spines on the middle leg, and their tarsal claws are not toothed. There appear to be seven British species, including the hornet,[2] although the number is stated by some authors to be eight. A hornet may be easily recognized by its size—a small worker hornet being larger than any queen wasp—and by its reddish-brown and yellow livery, all the "wasps" being black and yellow, and very much alike in appearance. The three commoner species usually build under ground, while two others generally hang their nests from the branches of a tree or shrub. A sixth species, of which no workers are known, seems not to build at all, but to breed in the nests of one of the ground species. The hornet builds as a rule in hollow trees, or in the roofs of outhouses, barns, etc.,

[1] *Eumenes coarctata.* [2] *Vespa crabro.*

though it occasionally makes subterranean nests. Social wasps store no food for winter use, nor do the communities hibernate like those of the ants. At the close of each season all the drones and the whole working population of the nest perish, only the young queens remaining alive. These, having mated with the drones before severe weather sets in, betake themselves to dry, sheltered hiding-places, where they lie dormant until the advent of spring. Then each comes forth, constructs a small nest, and lays a few eggs therein. From these small beginnings the great wasp communities of the late summer develop. The queen's fertility seems well-nigh inexhaustible, and for many weeks only workers are produced. In this way "labour" is provided for the enlargement of the nest, and for the nurture of the queen's enormous family. This amazing multiplication of sexless units continues until the autumn, when the drones and young queens —destined to secure the continuity of the species—are reared. The material used by wasps for nest-building is really a kind of paper, made from wood or other vegetable fibre, worked up with the insect's saliva. The nest is not built up from a foundation as we build a house, but is hung from some support, such as a branch or root. It consists of combs of hexagonal cells, in which the grubs are reared, and an outer cover. The latter is continually cut away and renewed as the combs are extended, or when new ones are added. Adult wasps are practically omnivorous, but they are especially partial to sweet liquids. It has been ascertained, however, that the food brought to the grubs consists largely of the soft parts of insects.

The great bee family[1] is represented in Britain by

[1] *Apidæ.*

some 200 species. These are divided into three main groups or sub-families, according to the length and structure of the tongue (hypopharynx). But all bees have certain characters in common which serve to distinguish them from other members of the order Hymenoptera. They are essentially flower-lovers, and feed their young exclusively on nectar and pollen. If we examine a bee's hairs under the microscope, we shall find that at least some of them are minutely branched, or plumose. That these specialized hairs are of great value in entangling and collecting pollen cannot be doubted, although this may not be their sole function, seeing that they are possessed, not only by the females and worker, but also by male bees and "cuckoo" bees, neither of which gather pollen. Bees may also be known by the enlargement of the basal joint of each hind tarsus. This joint, which in many instances is as broad as the tibia, is termed the metatarsus or planta. It often plays an important part in the work of pollen-gathering, stiff hairs on its inner surface serving to rake or brush the pollen grains from the hairs of the body. But different kinds of bees collect and carry home their pollen in different ways. Indeed, the appliances and methods are so varied, and in many cases so little understood, that they present a wide field for investigation and discovery. By far the larger number of our native bees are solitary in their habits. Many make their nests in burrows, either in the ground, in wood, or in the pith of plant-stems. Others take advantage of existing holes and crannies—in this respect resembling some of the solitary wasps. The cells which contain the grubs and their supply of food may be mere chambers excavated in the soil. But the

mason-bees build their cells of sand or earth cemented together with their own saliva. The leaf-cutter bees[1] use pieces of leaves, which they cut from the living plant. Other species form their cells of wax or other material secreted from their own bodies. One, known as the wool-carder bee,[2] envelops its nest of waxen cells in a mass of white down collected from the leaves and stems of certain plants. The cuckoo-bees, of which there are several genera, do not make nests at all, but lay their eggs in the cells of other species, on the fruits of whose industry the cuckoo's grubs fatten. Some of the so-called solitary bees form colonies, many individuals building their nests in close proximity; but true social communities, comprising workers as well as females, are formed only by the humble-bees[3] and the hive-bee.[4] Some species of humble-bees nest in subterranean chambers, others—the "carders"—beneath piles of moss, etc., on the surface of the ground. Their communities, like those of social wasps, persist for one season only—the perpetuation of the species depending upon fertile females, or queens, which hibernate and found new nests each spring. Hive-bees alone dwell in "abiding cities."

[1] *Megachile.*
[2] *Anthidium manicatum.*
[3] *Bombus.*
[4] *Apis mellifica.*

OUTLINE CLASSIFICATION OF BRITISH INSECTS

Class: Hexapoda (or Insecta).

Sub-class: Apterygota (wingless insects).
Order 1. Aptera.
Sub-order: (*a*) Thysanura (Bristle-tails).
Sub-order: (*b*) Collembola (Spring-tails).

Sub-class: Exopterygota (wings developed visibly outside the cuticle).
Order 2. Dermaptera (Earwigs).
Order 3. Orthoptera (Cockroaches, grasshoppers, crickets, etc.).
Order 4. Plecoptera (Stone-flies).
Order 5. Corrodentia.
Sub-order: (*a*) Copeognatha (Book-lice, etc.).
Sub-order: (*b*) Mallophaga (Biting-lice).
Order 6. Ephemeroptera (May-flies).
Order 7. Odonata (Dragon-flies).
Order 8. Thysanoptera (Thrips, or flower-insects).
Order 9. Hemiptera.
Sub-order: (*a*) Heteroptera (Bugs).
Sub-order: (*b*) Homoptera (Frog-hoppers, aphides, scales, etc.).
Order 10. Anoplura (Lice).

Sub-class: Endopterygota (wings developed beneath the larval cuticle, only visible after penultimate moult).
Order 11. Neuroptera (Alder-flies, lacewings, etc.).
Order 12. Coleoptera (Beetles).
Order 13. Mecaptera (Scorpion-flies).
Order 14. Trichoptera (Caddis-flies).
Order 15. Lepidoptera (Butterflies and moths).
Order 16. Diptera.
Sub-order: (*a*) Orthorrhapha (Midges, gnats, crane-flies, etc.).
Sub-order: (*b*) Cyclorrhapha (Hover-flies, house-flies, bot-flies, etc.).
Order 17. Siphonaptera (Fleas).
Order 18. Hymenoptera.
Sub-order: (*a*) Symphyta (Saw-flies).
Sub-order: (*b*) Apocrita (Gall-wasps, ichneumons, wasps, ants, bees, etc.).

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